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在 Moodle 學習管理平台上的註解與學習歷程模組

The design and implementation of
annotation and portfolio modules for
Moodle LMS

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摘　　　要

在現在的教學環境中，線上學習已經扮演一個不可或缺的角色，教師們已習慣利用學習管理系統作為他們的教學平台。而隨著 WEB2.0 的概念出現，網路成為一個貢獻與分享的互動平台。使用者在網路上不再只是單純的閱讀內容，而是進一步的成為內容的提供者。

現存的眾多學習管理系統中，moodle 開放源碼平台是最為廣泛採用之一。在老師將教材放到 moodle 的同時，我們希望同學能夠直接線上閱讀這些教材，而不再需要另外下載回電腦中，並且將傳統上對紙本教材做筆記的動作，在線上教材也能實現，基於這些需求，我們開發了第一個模組：學習筆記模組系統。同學們除了以往只看到自己的筆記之外，還可在線上看到其他同儕對相同教材的學習心得，達到合作與分享的學習，老師也可藉由查看同學們的註記，了解同學的學習狀況，作為日後教學的基礎。

各種傳統的教學行為都可透過 moodle 的學習活動實現並得到良好的管理，這些學習活動完整的紀錄了學生的學習狀況。因此我們開發了第二個模組：學習歷程模組。此模組完善的整合 moodle 的學習活動，並結合學習筆記模組，將這些學習筆記教材封包成 SCORM 教材包，達成跨平台間的溝通交流。

The design and implementation of annotation and portfolio modules for Moodle LMS

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ABSTRACT

   Learning management system plays a critical role in current pedagogic environment. Along with the concept of WEB 2.0, web has become an interactive platform for contribution and collaboration. Moodle open source LMS is one of the most popular learning management systems currently published. It will be valuable for the learners to view the teaching materials online and perform annotating operations on them which are traditionally executed on paper-based materials. To meet these requirements, the first module: Learning Annotation for Moodle (LAM) is proposed. Students can see both their own annotations and different thoughts in other students' mind. Instructors can promote the tuition by viewing students' annotations.

   Conventional education actions can be conducted and administered through the usage of moodle activities. These activities record students' learning performance completely. Another module is proposed hence: Annotation Portfolio for Moodle (APM). This module integrated well with moodle activities. It also couples LAM together and packs the annotations into SCORM package to be interoperated between distinct LMSs.

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也感謝所有分散式系統實驗室的夥伴及學弟妹：羅國亨，洪偉翔，鄭婷文，劉嘉倩，洪銘鴻，黃昱凱等。有你們這些可愛的朋友陪伴，讓我最後一年的學生生活過得非常的開心快樂。

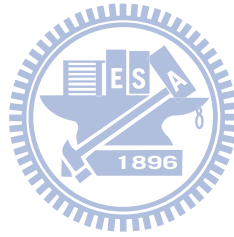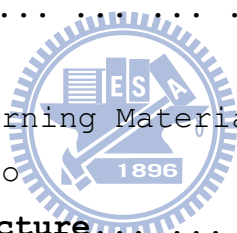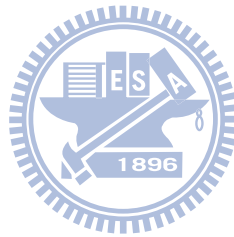最後感謝我的父母以及我的家人，雖然多花了些時間念完研究所，不過你們並不會責備我，而是給予我自己的空間，一直陪在我身旁，讓我無後顧之憂的完成我的學業，謹以此文獻給我摯愛的家人。

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Chapter 1 Introduction

1.1 Motivation

Nowadays the teaching mode has been shifted to online learning gradually together with the innovation of computer and internet. Teachers establish their courses in the Learning Management System (LMS), such as ATutor[19], Blackboard, and Apex Learning. They are also willing to upload their teaching lectures involving web based and file based materials to these LMSs. The responsibility of LMS is to manage the processes surrounding learning. A standard functional model of LMS is depicted in *Figure 1 − 1* adapted from [14] containing two main components: "Course Engine" and "Profile Engine".
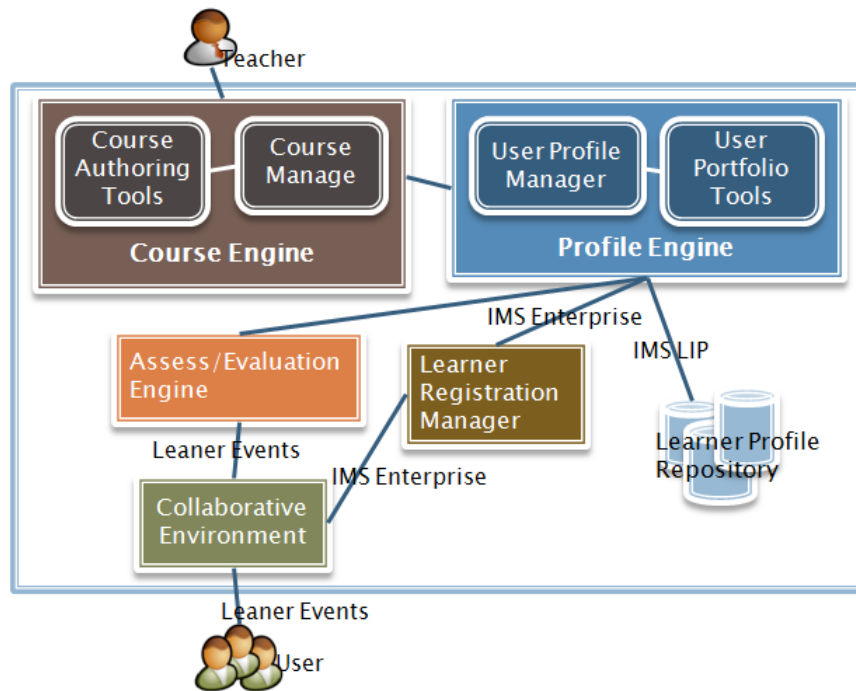
Figure 1 - 1 Functional Model of LMS

Another emerging concept applied in pedagogy is EDU2.0, also known as e-learning 2.0[15][16][17][18], coupled with the idea of WEB2.0[12][13]. WEB2.0 stands on end-users' perspective. One of the WEB2.0's characteristics is convergence. It emphasizes on sharing and

collaborating among end-users. "The user is the content" is the most significant conception of WEB2.0. The web pages are enriched by user experiences. Consequently, EDU2.0 makes students a contributing factor in pedagogy. It enables students to participate in a many-to-many information sharing operation and moves traditional teacher-centered lecturing structure to student-centered learning.

The LMS provides a platform to allow interactions between the students and the tutors, as well as among the students. Most of the conventional pedagogic activities can be successfully converted into e-learning environment, for instance, having discussion in a community forum, submitting online homework, and holding semester examination. Marking down personal notes on the teaching materials is another classic and frequent learning behavior to emphasize the great parts of a document[19]. Aiken et al. indicated materials those were in a student's notes were twice as likely to be recalled as materials which weren't in the student's notes[21]. Students are able to peruse the materials uploaded, nevertheless, there is no such functionality in current existing LMS to let students affix annotations on them so far as our knowledge.

As the conventional education actions can be conducted and administered through the usage of LMS, these actions record students' learning performance and there should be a mechanism to pack them to provide performance-based assessment.

1.2 Research Objectives

Two modules for the moodle LMS are proposed in this thesis concerning the two major components, course engine and profile engine, in LMS's functional model respectively.

In order to address the issue of annotating digital learning materials, the first moodle plugin: Learning Annotation for Moodle (LAM) is proposed in accordance with the notion of EDU 2.0. Since the

web-based materials can be viewed online and being annotated via existing web application, LAM module focuses on the file-based lectures those have been uploaded to moodle repository. LAM is characterized by the following three properties:

- Viewing file-based materials online.

    Like viewing the web-based materials online, the file-based lectures can be seen on moodle directly via LAM.

- Attaching annotation on material.

    LAM module provides a platform to let students mark up their thoughts onto the digital lectures as they did on the paper lectures.

- Share and collaboration with peers and faculty.

    For the sake of interactive and collaborative learning, the annotations attached are categorized and administered by LAM to be shared among learners.

In the profile engine, students' information and learning status are recorded including those education actions conducted on the LMS. The second module, Annotation Portfolio for Moodle (APM), is hence proposed to encase these records as a learning portfolio. Besides, APM copes with another considerable subject: there are myriad of distinct learning management systems existed. APM supplies an exchangeable SCORM material package to be interoperated between different LMSs.

1.3 Outline of the thesis

In the following chapters, the backgrounds about annotation and portfolio on learning perspective are discussed in chapter 2. Chapter 3 outlines the architectures of moodle LMS and our modules. Based on these architectures, the implementation details are described in chapter 4. The evaluation is in chapter 5 containing the comparison

and an experiment for LAM module. Finally, the conclusion and future works for our proposed modules are presented. We give the user guide in the appendix showing how to utilize our modules.
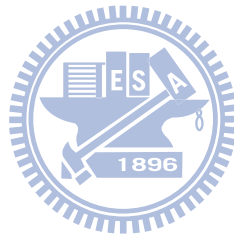
Chapter 2 Background

2.1 Moodle LMS

E-learning is an interactive learning in which the learning content is available online and provides automatic feedback to the student's learning activities, hence Learning Management System (LMS) is becoming an important part of the strategy for delivering online and flexible e-learning to facilitate study. There exists more than 250 providers of e-learning systems[3], including commercial and open source software (OSS) products. One of the well-known OSS projects is Modular Object-Oriented Dynamic Learning Environment, abbreviated as Moodle[1][4].

Moodle is designed based on Social constructionist pedagogy, which is a learner-oriented philosophy. According the statistics in the official moodle site till June 2009[1], moodle has been widely adopted in 200 countries, has currently larger than 40,000 registered sites, and the number of courses is in excess of 2,400,000. Most importantly, there are about 690,000 participators in the moodle community where educators can share their teaching experiences and developers of moodle modules can get needed information there.

Several researches have concluded that moodle is one of the best learning manage systems[3][5][6][7]. Ajlan and Hussein [3] compare moodle versioned 1.8 with other nine popular LMSs, involving Desire2Learn 8.1, KEWL, ANGEL Learning Management Suite 7.1, eCollege, Blackboard, Claroline 1.6, Dokeos 2.1.1, OLAT, and Sakai 2.3.1, to testify their features and capabilities in three aspects: learner tools, support tools, and technical tools with more exhaustive subcategories respectively. As listed in *Table 2 – 1*, moodle is one of the most robust LMSs which satisfies 38 of 40 features and just misses two.

Table 2 – 1 Features and capabilities[3]

No	1	2	3	4	5	6	7	8	9	10
product	Desire2Learn	KEWL	ANGEL Learning	eCollege	Blackboard	Moodle	Claroline	Dokeos	OLAT	Sakai
Total Features: 40 (Learner / Support / Technical Tools)										
Available	37	35	37	33	35	38	32	33	35	38
Missing	3	5	3	7	5	2	8	7	5	2

Graf and List[6] take into account of the significance of e-learning platforms' adaptation since a learning platform should match students' demands and desires as closely as possible, and adapt during course progression. They use qualitative weight and sum (QWS) approach and pairwise comparison between all platforms to analyze the adaptation of a LMS and determine its ranking. The evaluation focuses on four phases which are adaptability, personalization, extensibility, and adaptivity where the appraisal result is enumerated in *Table 2 – 2* and moodle can been seen as the best platform regarding adaptation issues.

Table 2 – 2 Adaptation of a LMS[6]

	Adaptability	Personalization	Extensibility	Adaptivity	Ranking
Maximum Values	*	#	*	*	
ATutor	|	#	#	|	3
Dokeos	|	0	*	+	2
dotLRN	+	+	*	0	2
ILIAS	+	#	*	0	2
LON–CAPA	+	#	#	|	2
Moodle	#	+	*	|	1
OpenUSS	#	#	#	0	2
Sakai	0	0	*	0	3
Spaghettilearning	+	#	+	0	3

* = extremely valuable, # = very valuable, + = valuable,

\| = marginally valuable, 0 = not valuable

Moodle is extensively introduced into our country as well. There are approximately 950 registered moodle sites in Taiwan[1]. *Figure 2 – 1* shows the current usage of moodle in Taiwan respecting higher education institutes. Tunghai University[7] and National Chi Nan University[11] have the grandest moodle site. Both of these two sites have more than 15,000 users and 3,000 courses. Tunghai's site is characterized by its usage frequency that there are 6,500 login students in average everyday and Chi Nan's site has been integrated with the system of academic affairs.
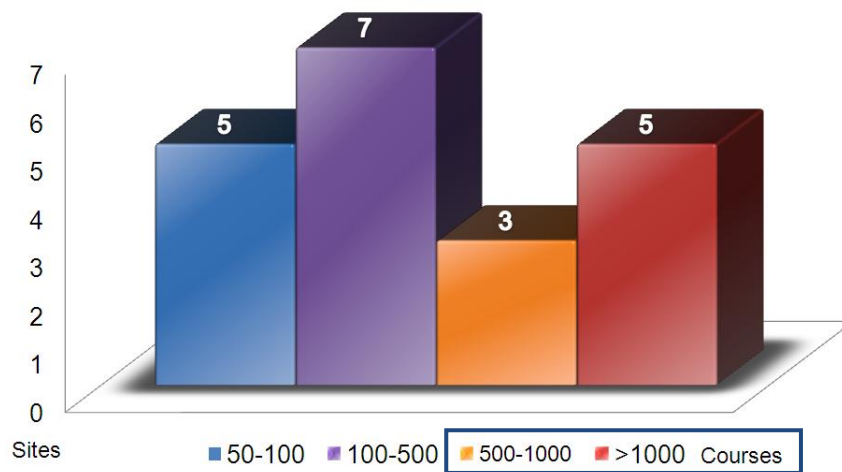
Figure 2 – 1 The Usage of Moodle in Taiwan

The overall advantages of moodle can be summarized as below[3][5]:
A. Moodle is an open source software.
B. Moodle can be installed on almost all servers that support PHP, such as UNIX, Windows and Macintosh.
C. Moodle supplies more than 40 kinds of languages.
D. Moodle possesses various types of Resources and Activities, including "lesson" activity to provide adaption.
E. Teachers can evaluate students' performance by employing Resources' and Activities' evaluation function.
F. Moodle can stimulate students' desire to master moodle's environment. Students are capable of choosing their own themes and lay out personal appearance.

G. Moodle has well-documented API, detailed guidelines, and templates for programming.

H. Moodle community has numerous participants to sustain required information and is continuing growing.

2.2 Annotation on Learning Materials

Annotation is an explicit "in-context" expression of knowledge in the form of comment, note, or other types of external remark which reveals conceptual meanings of annotators' implicit thought. It may be employed by the learners and lecturers for three tasks[28] to facilitate collaborative studying and personalize the learning content:

A. "Extensive Annotations": This kind of annotations contains additional information to enrich the learning materials and foster deep reading.

B. "Intensive Annotations": Annotations can be treated as personal notices. This promotes knowledge construction and assists in the cognitive domain of educations activities.

C. Annotations can also be used as a route of communication embedded in documents. This provides a natural way to communicate ideas and feedback.

The annotation skills applied on learning materials currently can be divided into three categories:

■ Web-based annotation

A myriad of tools have been proposed to allow the insertion of annotations directly onto web pages[25][26][27]. Ying and Jia-Hou[30] presented to apply Diigo[22], a burgeoning tool of such kind, in education perspective. Though these tools functioned-well in supporting collaborative learning and supply timely interactions between lecturers and students, they don't

combine properly with teaching materials. Teachers utilizing these tools need to transform their lectures into web(html) format once more.

■ Device-driven annotation

Integrated Textbook[29] and PAM[26][27] proposed another kind of annotation scheme. Both of them were devised for didactical purpose and worked well on teaching lectures. Students can operate them as traditional paper-and-pen based approach. However, these two systems need the help of other electronic devices, like graphic tablet and digital pen. Furthermore, they also don't integrate with existing LMSs.

■ On-line presentation

Such kinds of technique, like Slideshare[23], provide a way to view materials online. These services currently focus on the share of lectures and support most formats of materials. The annotations made on these applications are material-wide. Learners can't mark up their thoughts on specific portions.

With regard to Moodle, there's no capability of attaching annotation on teaching materials built in neither current Moodle's released packages (until version 1.9) nor in the future roadmap (version 2.0). Two moodle plugins have a little similar function of annotating and collaborative learning: Advanced Book[7] and Quick Comments Block[9]. Advanced Book permits commenting and highlighting on the lectures but it only supports textual materials and teachers need to spend extra endeavors to prepare these materials. Quick Comments Block aims at interacting more conveniently between students and faculty, yet not among peers. It doesn't have any annotation ability as well.

2.3 Learning Portfolio

A learning portfolio is a systematical and purposeful collection of student work that tells the story of the student's effort, progress, or achievement in given areas[40]. Portfolios provide a natural and effective means of performance-based assessment by allowing the learner to display a variety of evidence of performance, such as products or exhibitions. Instructors assess students' learning performance by the content of their portfolios instead of traditional paper and pencil tests.

Portfolios can motivate students to learn because they have the power to make connections between theory and practice[33][34][35]. They afford the learners with a specific method to evaluate their own learning situations, covering all the records of the learners' activities during the learning process.

Portfolios encourage student-teacher relationship and collaborative learning process as well. By using portfolio data, the students and teachers are provided an understanding of both the former learning effects and later lecturing effects. The educators can immediately familiarize themselves with the students' learning situations and behaviors through the analysis of the students' learning portfolios and try to guide the students with poor learning effects.

Julie[36] presented a review of learning portfolio and pointed out that portfolios offer the advantages below:

A. Portfolio provides views of student growth and Invites self-evaluation.

B. It encourages student and teacher creativity.

C. Portfolio can show progress towards long-range goals and link learning to the world of work.

D. Portfolio encourages the use of integrated activities with emphasis on depth of learning.

E. Portfolio represents actual learning experiences and provides evidence of performance beyond acquisition of factual knowledge.

F. Learning portfolio offers opportunities for improved student self-image.

G. It increases students' responsibility for their own learning and intrinsic motivation.

H. Portfolio incorporates examples of student's higher-level thinking and problem solving.

I. Learning portfolio can be used by teachers to monitor class progress and feedback is provided from students and parents.

J. Portfolio encourages a collaborative effort between teachers and students.

K. Portfolios help to increase awareness of the abilities of special populations.
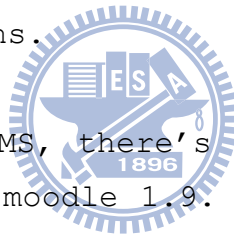
In terms of moodle LMS, there's also no built-in feature for learning portfolio till moodle 1.9. But moodle will comprise the portfolio module in moodle 2.0 which is still under developed. There are presently three third-party portfolio plugins submitted to moodle: "Exabis ePortfolio[37]" and "Simple Portfolio[39][40]". Each of these three modules has its own specific characteristics; nevertheless, all of them don't integrate with moodle's "activities". Our learning portfolio module combines some valuable features from these three plugins and couples well with moodle's "activities".

Chapter 3 System Architecture

Before detailing our system implantation, we portray the structure of our proposal in the ensuring subchapters. First of all, the architecture of moodle modules is depicted. Next to this framework, the rest of sections describe the framing of our designed modules: LAM module and APM module.

3.1 Moodle Modules

3.1.1 Module vs. Block

Moodle is a module-based learning managing system as implied in the fore of moodle's name: "Modular Object-Oriented". The administrative functions are encompassed within non-extensible folders. The functions in moodle are composed of three main portions which are **Activities**, **Resources**, and **Blocks** as illustrated in *Figure 3 – 1*. Each of these functions is wrapped as an individual module and packed into a folder in moodle package.
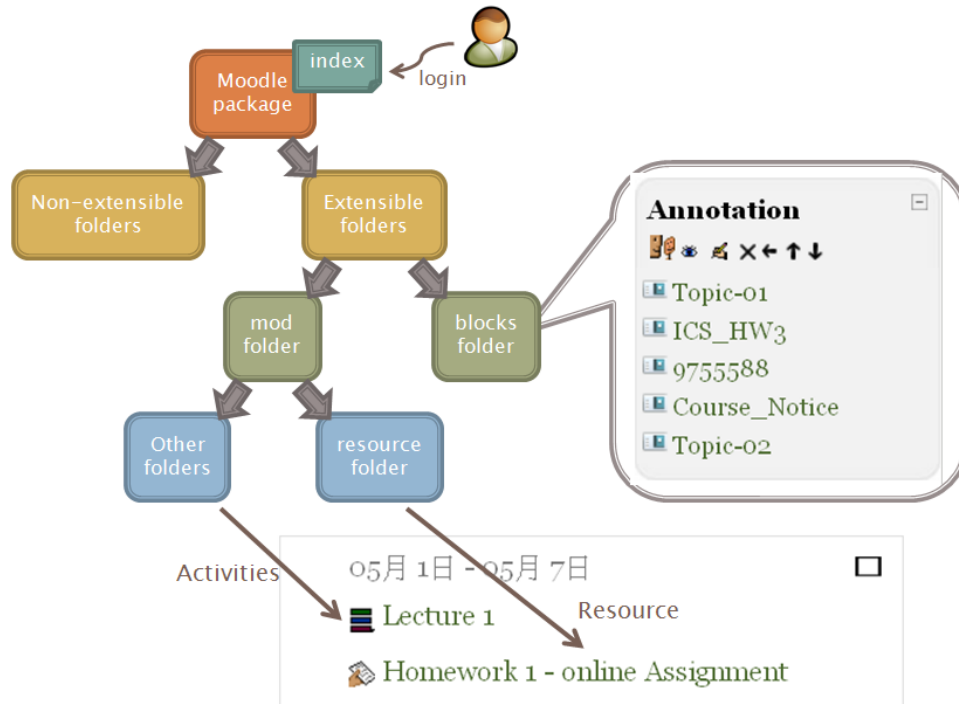

Figure 3 – 1 The Construction of Moodle Module

Those modular components in moodle LMS can be divided into two classifications which are "module" and "block". **mod** and **blocks** are the chief folders in moodle's package on behalf of these two primary constituents respectively. All the **Blocks** functions are located at the **blocks** catalogue directly where the **Activities** and **Resources** functions are collocated in the **mod** directory. Taking a deep look at the **mod** folder, the **Resources** facilities are gathered at the **resource** subdirectory while the **Activities** faculties are spread around the directory, for example, the "Compose a web page" resource feature is packed as **html** folder inside the **resource**.

3.1.2 Why Block

Following the conceptual exposition characterized previously, the physical appearances within a moodle site of these modular objects are demonstrated as the bottom of *Figure 3 – 1*. Although "module" and "block" are both modular composition units for moodle, they have quite different viewpoints that the first one is presented link-by-link and the other one is concentrated within area.

Concerning **blocks** perspective, each block component is viewed as a separate division arranged at either side in the web page. In contrast with **Blocks** feature, every function of **Activities** and **Resources** is displayed as a hyperlink enumerated in the middle section of course page such as the "online Assignment" resource above.

In our proposed modules: LAM and APM described in the succeeding paragraphs, LAM gives a list about the teaching materials which are allowed to be annotated and APM offers some choices to manage the portfolio. If these two plugins are implemented through the usage of either **Activities** or **Resources**, the configuration process would be too complicated for teachers to make use of our modules. Teachers would require performing subsequent action again and again: adding a new activity for his new lecture and deleting it while the lecture is altered or not used any more. These are pretty trifling time-consuming

operations. The **Blocks** scheme put all the items together inside the block and teachers only need to add the **Blocks** once. It is also very clear for students to see all the materials within one block. For these reasons, **Blocks** is chose as our implementation paradigm for both modules.

3.2 LAM (Learning Annotation for Moodle)

LAM is the most significant module of this thesis. *Figure 3 – 2* delineates how the LAM module is structured. Currently there aren't any capacities consolidated with existing learning management systems for allowing learners to attach annotations about their thoughts on the teaching materials though educators are willing to adopt some kind of LMS as their tuition platform and upload their lectures to the LMS repository. LAM module is planned to address this critical issue and pays attention to two major points:

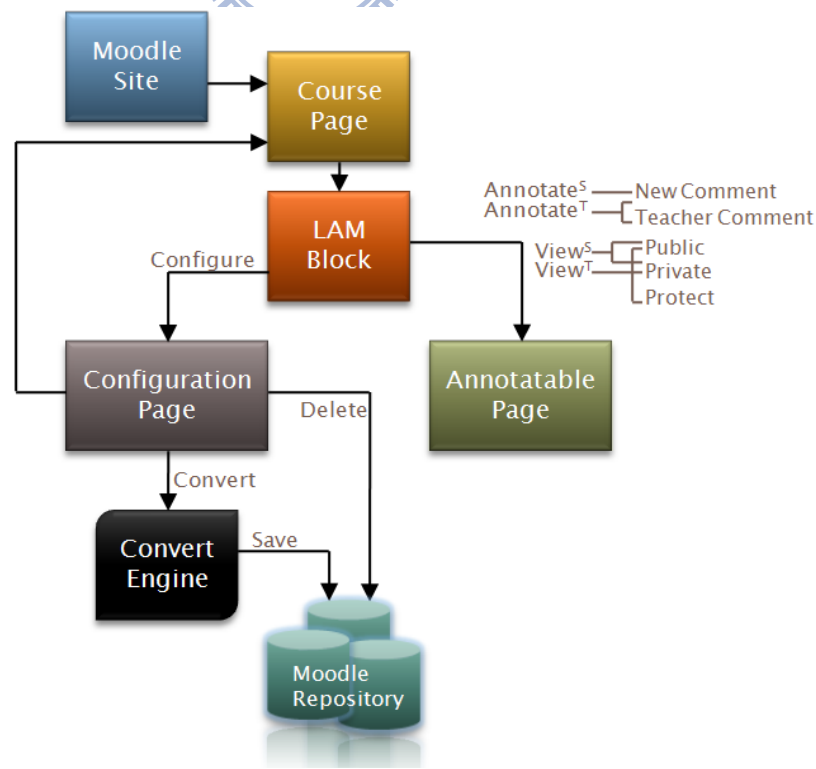1. How to display the teaching materials?
2. How to manage the annotations?

Figure 3 – 2 The Framework of LAM

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3.2.1 Material Management

In conventional practice, instructors place their lectures at the LMS storage and utilize other facilities, for instance, office software or online presentation web site to display these lectures and perform their tuition at class. If students want to review the teaching content, they are forced to download these materials to their own computer. They are not capable of reading the matter via the LMS straightforwardly except the materials which are web-based. "Presentation" and "Reposition" manipulations are not coupled together within LMS.

To cope with this "Display" issue, LAM attempts to transform the teaching lectures which are already uploaded to moodle's repository. At present, LAM module is designed for the lectures with "PowerPoint" format which is the most popular way used as lectures' fabrication form. The first action teachers need to do when utilizing this LAM module is "*Configure*" the lectures intended to be annotated by the learners. Those "PowerPoint" materials are converted into slide *images (.png)* format like the method Ferretti[24] et al. used in their Wiki-like annotation system.

This transformation operation is acted on the files existed in moodle database to reduces the times of uploading lectures and is accomplished through the employment of another "Convert Engine" that isn't built in moodle LMS. After performing the "Configure" execution, lecturers and learners are able to view the teaching materials online within moodle LMS and insert annotations on these converted lectures.

3.2.2 Annotation Management

Mohamed et al.[28] made a demarcation between two different approaches to the annotation of content. These are the "metadata-driven" and the "mark-up" annotation modes. In metadata-driven means, one refers to the annotation of learning

objects using metadata supplying descriptions of the e-Learning content. The end learner has little, to no control over the annotations made. Different from this approach, the mark-up annotations rely on the end users to make their own customizations to the teaching content. LAM falls under the latter category.

Three types of commentaries are defined in the LAM module for annotating the materials. They are "*Private*", "*Protect*", and "*Public*" annotations classified in *Table 3 - 1*. Private annotations are the most restricted ones. They are exclusive to the user who created them. In certain situations, learners may merely add an annotation for temporary information or wants to keep some comments for personal usage. "Private" is raised for this sake.

"Protect" and "Public" originate from the conception of communication. They are founded on collaborative and interactive e-learning to encourage the interactions among studying peers as well as shrink the gap between the educators and learners. Other than these three forms of annotations, teachers can mark up additional comment about students' annotations, i.e. the "*Annotate^T*" operation in *Figure 3 - 2* to evaluate each student's learning performance.

Table 3 - 1 Annotation Privileges

Access Level	Allowed Viewers
Private	Annotator himself
Protect	Annotator himself and the teachers of this course
Public	All the peers of this course

The last manipulation in our learning annotation module is the "*View*" operation that simply denotes reading the lecture slides and viewing the annotations appended on this material. Because of the second variety of access level: "Protect", the "*View^T*" instruction let the faculty to see the protected annotations which can't be seen by normal users. Learners give feedbacks about the lecture and communicate with teachers through this way.

3.3 APM (Annotation Portfolio for Moodle)

Another moodle plug-in proposed in this thesis is the "Annotation Portfolio" Module as constructed in *Figure 3 - 3*. The APM module is characterized by integrating well with moodle **Activities**. Notwithstanding the "SPDC Portfolio[38]" has taken the moodle assignment that has been submitted into consideration, it didn't involve other activities. **Activities** plays a major role in moodle LMS. Conventional teaching actions can be performed by means of **Activities**, for example, educators can hold an exam via the "quiz" activity. Students' effects for specific course during learning process can be recorded and revealed through the inspection of **Activities**. By coupling with **Activities**, APM is capable of affording useful information and evidence for assessing students' studying performance.
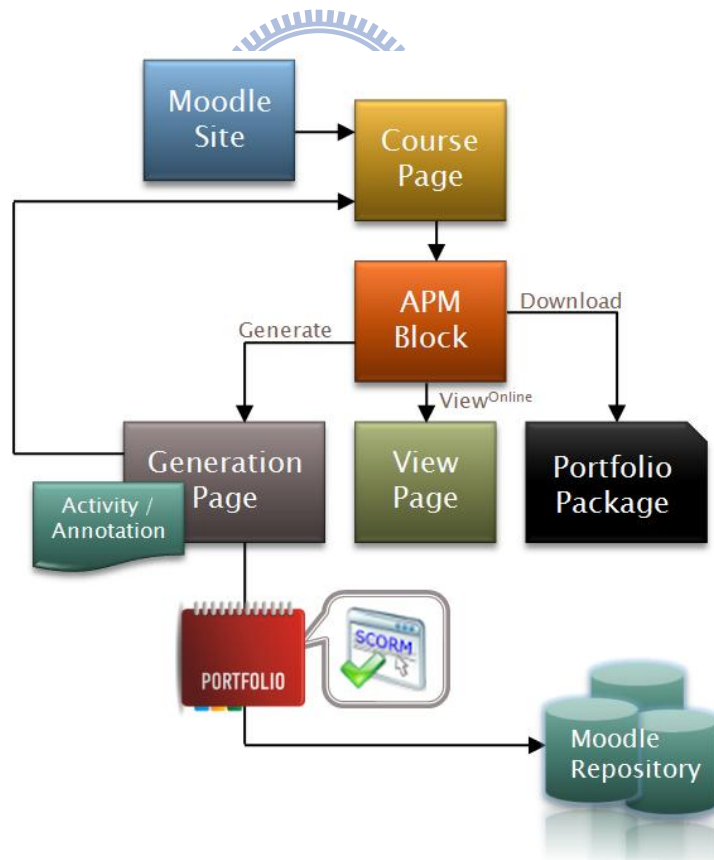

Figure 3 - 3 The Framework of APM

Matsuura et al.[41] stated the general requirements while developing e-portfolio system. These requirements are (i) Interoperability, (ii) Feasibility, (iii) Flexibility, (iv) Compatibility, and (v) Autonomy. Following these principles, we provide diversified options within the "*Generate*" operation of APM module to permit users selecting the items they desire to put into their portfolio packet as the way applied in "Simple Portfolio[39][40]". The generated learning portfolio is stored in the "portfoliodata folder" at moodle repository and can be viewed immediately via the "*View^Online*" manipulation. In case users want to preserve their own portfolio, a "zip" portfolio package can be downloaded by the "*Download*" instruction.

The APM module integrates with the LAM module as well. Learning annotations inserted on the teaching materials are one kind of collections demonstrating students' progress over time. Supposing the administrator or the faculty of moodle had installed LAM block in certain course, users of this course are able to pack the annotations into portfolio. This APM module would still function properly even though the LAM module isn't installed.

When a user involves annotations as one of his portfolio selections, a scorm package for these annotations is produced[37]. Scorm (Sharable Content Object Reference Model) is presented by ADL[31] to leverage course development investments. Scorm intends to make teaching materials "reusable", "accessible", "interoperable", and "durable". This objective chimes in with Matsuura's portfolio requirements. The scorm package created by APM is consisting of chosen materials and the annotations associated to these materials to maintain interoperability. The generated scorm package can be viewed in both moodle and other learning management systems those are scorm-compliant.

Chapter 4 Implementation Details

Going with the architecture characterized in Chapter 3, Subchapter 4.1 spells out how to construct a new moodle block. Based on these moodle specific instructions, Section 4.2 and 4.3 delineate the methods and structures utilized in our modules: LAM module and APM module.

4.1 Moodle Block

Figure 4 – 1 depicts the major constituting elements in a standard moodle block. For a start, two indispensable elements are created inside the **blocks** folder:

1. A new folder named as your block name, "plugInName".
2. A php format file named as "block_plugInName": main file of moodle block.
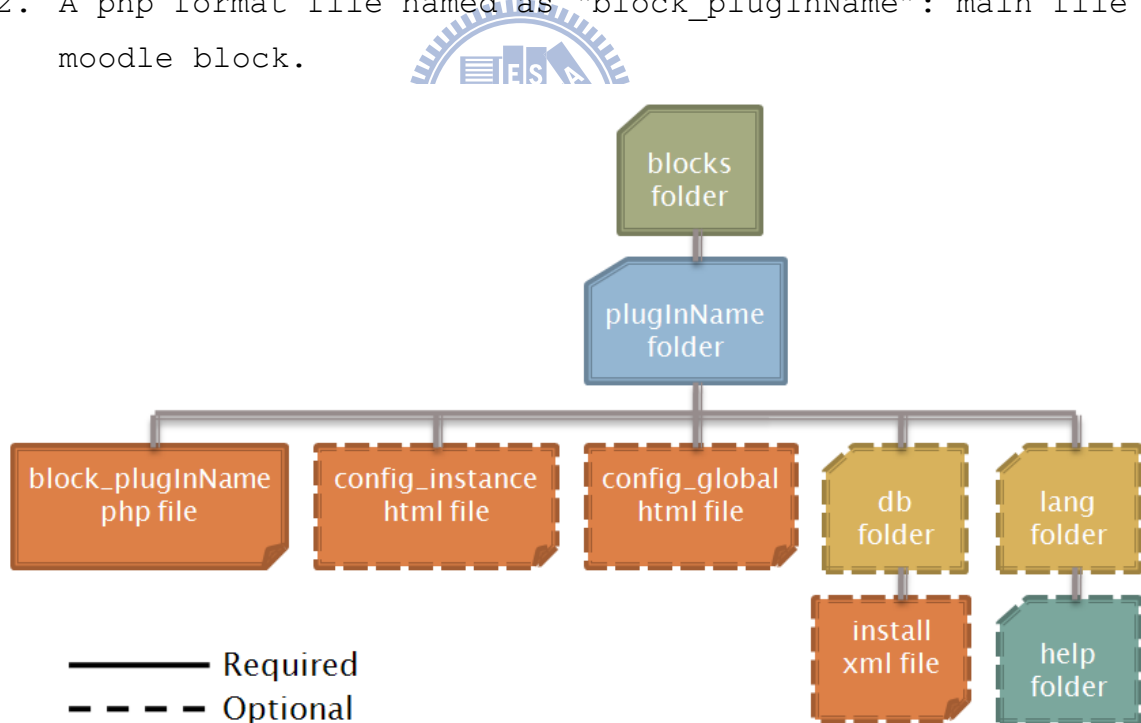

Figure 4 – 1 Major Elements inner Moodle Block

Since each module is encased as a folder in moodle package, whole associated folders/files is placed within the plugInName catalogue.

Being an essential file, block_plugInName masters moodle block. It controls the content showed inner the block and maintains the appearance of block. The remains excluding block_plugInName in the plugInName directory are all optional including the following:

- config_instance / config_global html files –

    Moodle allows developers to provide configuring operations for their blocks. These two files supply instance level and global (block) level configuration respectively.

- db folder –

    Moodle offers an effortless and expeditious manner, XMLDB, to conduct database. Programmers can utilize the XMLDB editor in moodle site or write by themselves to build a "install" xml file in this db folder to manage database tables.

- lang / help folders –

    Moodle supports internationalization as well. The localized information and help documents are collocated here.

While creating a new block_plugInName php file, two categories of blocks are able to be chosen to determine how the content is displayed:

- BLOCK_TYPE_TEXT –

    This kind of block will appear as a normal textarea. Both HTML syntax and textual description can be used.

- BLOCK_TYPE_LIST –

    This list is displayed with one item per line and an optional image (icon) next to the item.

Moodle is outstanding in programming assistance. It affords the developers well-documented programming APIs[2] and comprehensive help documents. The core variables and functions in moodle and block are itemized in *Table 4 – 1* and *Table 4 – 2* individually. All the set up information about moodle site can be retrieved from $CFG variable.

Programmers can make use of $USER and $COURSE to probe which course
current user is located in. Inner the block_plugInName main file, this
program begins with init(). Those preactions in advance of delete and
postactions in back of install are specified in before_delete() and
after_install(), respectively. In case this block can be configured
by admin/faculty, has_config() would set "True" as its return value.
The matter showed in block is embraced in $this->content. Programmers
simply put the content here and manage it by way of get_content() and
specialization().

Table 4 - 1 Core Variables in Moodle

	Variable Name	Variable Description
Global Variable	$CFG	Containing all the moodle configuration parameters.
	$USER	Pointing to current user who uses moodle.
	$COURSE	Pointing to current course being assessed.
	$SITE	Pointing to moodle site homepage.
	$DB	Pointing to moodle database repository.
Block Variable	$this->content	Holding all the actual content that is displayed inside each block.
	$this->config	Holding all the specialized instance configuration data that have been provided for this specific block instance.
	$this->content_type	Instructing moodle on what type of content it should assume the block has.
	$this->instance	Holding all the specific information that differentiates one block instance from another.
	$this->title	Containing the human-readable name of the block.
	$this->version	Holding each block's version number.

Table 4 - 2 Core Functions of Moodle Block (block_plugInName.php)

	Function Description
after_install()	Specifying a set of tasks to be executed after the block is installed.
applicable_formats()	Controlling which pages your block can be added to.
before_delete()	Performing any necessary jobs/cleanup before the block is deleted.
get_content()	The content displayed in your block should be prescribed here.
config_print()	Choosing how to display the global configuration screen for your block.
config_save()	Overriding the storage mechanism for your global configuration data.
has_config()	Denoting whether your block wants to present a configuration interface or not.
init()	Initial function of block. Assigning meaningful values to the object variables $this->title and $this->version.
instance_allow_config()	Denoting whether your block wants to have per-instance configuration or not.
instance_allow_multiple()	Indicating whether you want to allow multiple instances of this block in the same page or not.
instance_config_print()	Choosing how to display the instance configuration screen for your block.
instance_config_save()	Overriding the storage mechanism for your instance configuration data.
refresh_content()	Causing your block to recalculate its content immediately
specialization()	Automatically called by the framework immediately after your instance data is loaded from the database.

4.2 LAM Block

In accordance with the criteria defined by moodle block above, LAM module and APM module are programmed. LAM is composed of two different portions which are "Configuration" portion and "Annotatable Page" portion.

4.2.1 Implementation Tools

Moodle is a web-based learning management system. It can be easily worked on a web server. All moodle's functions can be operated via web browser directly. Moodle nominates PHP as its conventional programming language. Most files contained in the moodle package are written in PHP format. In addition to PHP, extra programming languages and skills are utilized involving Javascript and AJAX. As for database repository, moodle supports MSSQL, Oracle, MySQL, etc. These different database products are integrated and interchanged via the XMLDB technique. Hence, other moodle sites can use our module seamlessly even if they choose different database repository than us. *Table 4 - 3* lists the tools used in both LAM and APM.

The latest version of moodle package is 1.9.5 currently and moodle 2.0 is under development so far. We choose moodle 1.8 as our based version since moodle had some unstable functions, such as MNet service, when we were programming our plugin. This choice doesn't impact on the functions provided in our module. The differentiations between version 1.8 and 1.9 are took into account while developing.

Table 4 - 3 Implementation Tools for LAM and APM

Moodle Package	Version 1.8
Web Server	Apache HTTP Server 2.0
Programming Language and Skill	PHP, Javascript, and AJAX
Database	MySQL 4.1
Supported Browser	MS Internet Explorer and Mozilla Firefox

Table 4 – 4 enumerates the four tables defined in LAM module. The first one is used in configuration portion and others are used in annotatable page portion. As LAM needs to convert the teaching materials into slide images, these data are stored in slideinfo to conduct the transformation and deletion. The rest handle the operations and functions about the annotations upon the annotatable page.

Table 4 - 4 Database Tables Used in LAM

	Table Name	Table Description
Configuration	mdl_block_annotation_slideinfo	Managing the information about the materials converted.
Slide Page	mdl_block_annotation_autorefresh	Controlling whether an annotatable page needs to be refreshed or not.
	mdl_block_annotation_comment	Holding whole the annotations and associated information of each annotation.
	mdl_block_annotation_slideuser	Containing the users those are reading right now.

4.2.2 Configuration

This configuration management is mainly implemented in config_instance html file and block_plugInName php file and can merely be performed by admins/faculty. It concerns two perspectives: (1) slide transformation and (2) module's set up.

LAM integrates well with moodle repository. While a teacher is performing the "Configure" operation, it automatically lists all the PowerPoint files submitted to moodle and filters out un-PowerPoint-formatted materials. The educator doesn't need to upload the lectures he wants to convert another time. Inside the "Configure", the educator can select the PowerPoint lectures to be transformed into slide images through the "Convert Engine" or erases the converted images.

Listing 4 – 1 and *Listing 4 – 2* show the pseudo code for slide transformation. In this stage, two database tables are utilized: annotation_slideinfo and annotation_autorefresh. config_instance HTML simply lists the slides to be converted/deleted while the actual execution is performed in specialization(). Once the slide is converted, a corresponding link for this slide is listed in the block. On the contrary, the link is removed when the slide is deleted.

```
<body>
  <convert tab>
    foreach(file in moodle repository) {
      if((file belongs to this course) &&
         (file type is ppt format) &&
         (file hasn't been converted)) {
        list file
        action = convert
      }
    }
  </convert tab>
  <delete tab>
    convertedSlides = get_records(annotation_slideinfo)
    if(count(convertedSlides) > 0) {
      foreach (convertedSlides as convertedSlide) {
        list convertedSlide
        action = delete
      }
    }
  </delete tab>
  submit back to block_annotation.php
</body>
```

Listing 4 – 1 Pseudo Code in config_instance HTML

```
specialization () {
  foreach (slide selected in config_instance) {
    if (slide.action == convert) {
      call convert engine
      convert slide
      save slide information into annotation_slideinfo &
           annotation_autorefresh tables
      store slide images into moodle repository
    }
    else {
      remove slide information from annotation_slideinfo &
             annotation_autorefresh tables
      delete slide images from moodle repository
    }
  }
}
```

Listing 4 – 2 Pseudo Code in specialization()

In terms of module's set up, there should be backup/restore actions to preserve the annotations added and associated slide information as showed in *Listing 4 – 3*. Before LAM module is uninstalled, the database records are backuped and an option of whether deleting converted images or not is provided. If the module has ever been used in this course and the converted slide images are preserved, those related records are restored back after LAM's installation.

```
after_install() {
   if((ever used this module before) &&
      (converted slides are preserved))
     restore annotation_slideinfo &&
             annotation_comment &&
             annotation_autorefresh tables
}

before_delete() {
   backup annotation_slideinfo &&
          annotation_comment &&
          annotation_autorefresh tables
   provide an option to delete slide images
}
```

Listing 4 – 3 Pseudo Code in before_delete() & after_install()

4.2.3 Annotatable Page

The annotatable page is the critical portion of LAM plugin. It handles the two issues discussed in Chapter 3: materials' displaying and annotations' managing. Because moodle block has limited display area as viewed in *Figure 3 – 1*, it is not suitable to display teaching materials within the block. Hence, the annotatable page is extracted from the block content and a new window will pop out for each teaching slide. The new popped window is independent to the moodle web site and the moodle block. Users can perform other moodle operations and view the learning materials synchronously. *Figure 4 – 2* exhibits the overview of the annotatable page used in our evaluation described in Chapter 5 where the DOM structure of annotatable page is decomposed in *Figure 4 – 3*.
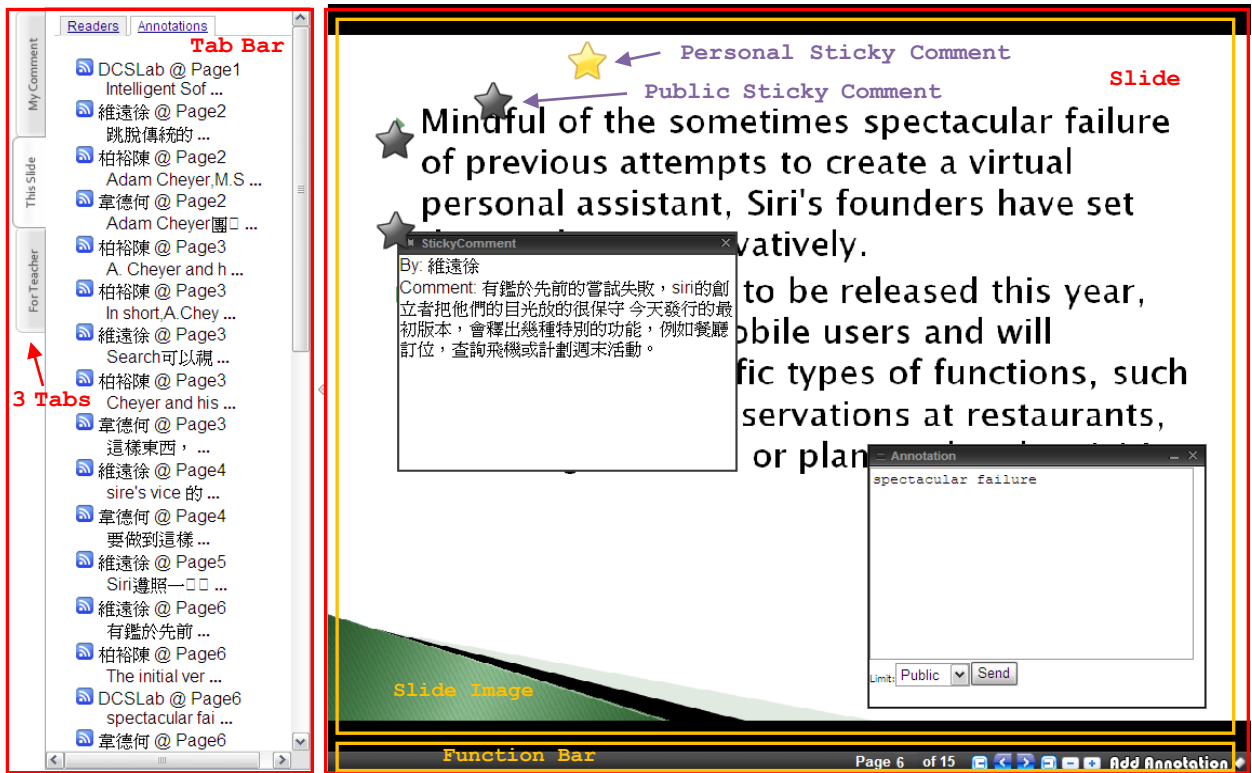
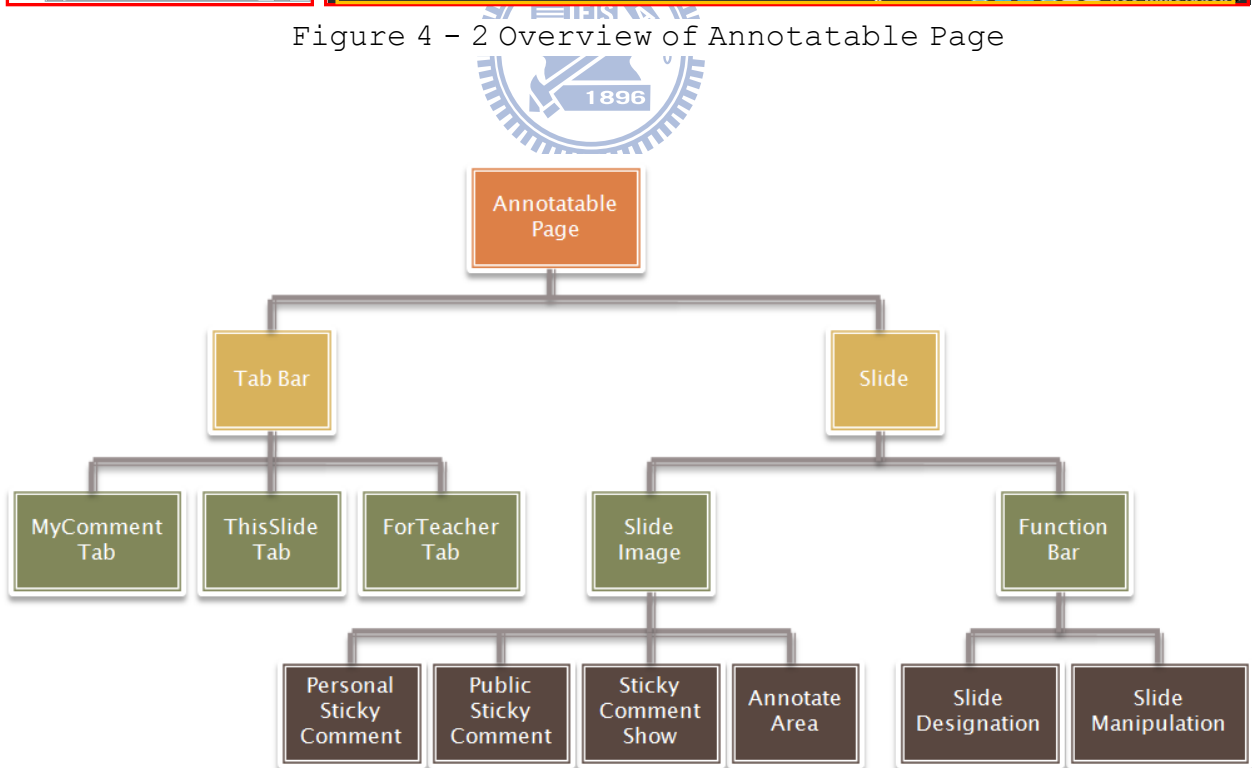Figure 4 – 2 Overview of Annotatable Page

Figure 4 – 3 HTML DOM Architecture of Annotatable Page

An annotatable page consists of two divisions, i.e. "Tab Bar" division and "Slide" division which controls annotations' managing and materials' displaying respectively.

- Tab Bar – (the left division in *Figure 4 – 2*)

    Tab Bar division provides a friendly user interface to manage the annotations of this slide containing three individual tabs: "MyComment" tab, "ThisSlide" tab, and "ForTeacher" tab. It has following characteristics:

    - Users can collapse and uncollapse to hide and show the tab bar like *Figure A – 4*.

    - User can see all his annotations in MyComment tab and goes to related page by click certain annotation.

    - ThisSlide tab maintains the social information of this slide. Students can know how many peers are currently viewing this slide in the "Readers" subtab and see all the public annotations made by other learners in the "Annotations" subtab.

    - ForTeacher tab is designed for faculty. Only the protect annotations would be showed here.

    - All the annotations showed in these tabs will be synchronized through the usage of annotation_autorefresh table while there are new annotations being created.

- Slide - (the right division in *Figure 4 – 2*)

    Slide division displays the teaching slides to the users page by page in the "Slide Image" area and is controlled in the "Function Bar" area.

    - Users are able to play the slide, jump to specific page, and zoom in/out the slide by employing the icons on function bar or corresponding mouse and keyboard manipulations.

    - A drag-and-drop based sticky note is attached onto the slide for each personal/public annotation. This would be a quite

convenient way to see the annotations for every page even though the tab bar is hidden.

◆ In addition to mark up three types of textual annotations by clicking the "Add Annotation" icon, tutors can comment students' protect/public annotations as well.

4.3 APM Block

The APM portfolio module emphasizes upon two features: (1) coupling with moodle *Activities* and (2) an interchangeable scorm package. We implement this module as HTML based portfolio for two considerations: (1) viewing the portfolio through the moodle site directly and (2) making it possible to view the portfolio at offline circumstance.

Figure 4 – 4 shows the user interface to generate portfolio. Four categories are supplied in APM: "Annotations", "Files", "Grades", and "Activities" where "Annotations" would appear in case LAM module has been installed in this course and eight subcategories of moodle activities are included in the "Activities". While the portfolio is generated, there will be a corresponding folder for each genus of the chosen selections in the portfolio catalogue and a corresponding tab in portfolio view like *Figure 4 – 5*.

Figure 4 – 4 Overview of Generate Portfolio

Figure 4 – 5 Overview of View Portfolio
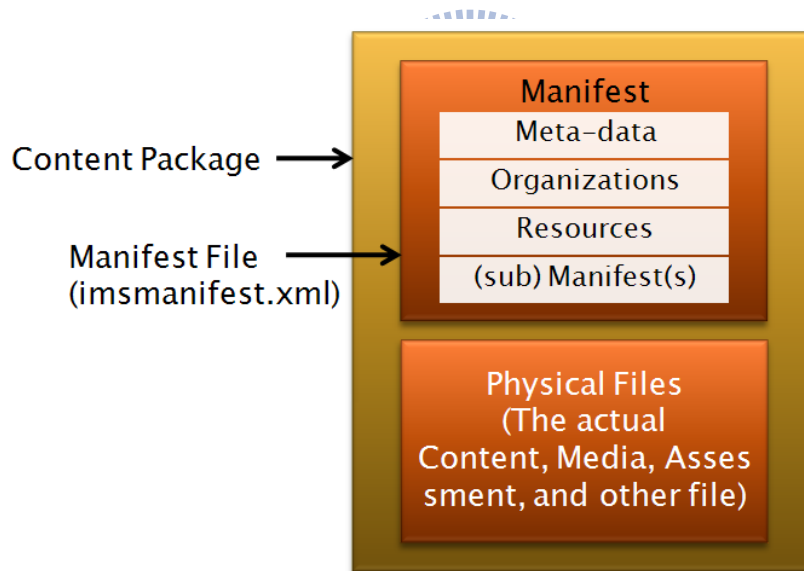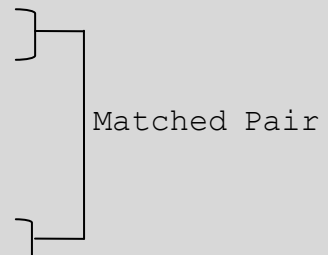
Figure 4 – 6 Concept Model of Scorm 1.2

Scorm 1.2[31][32] is adopted as our scorm package version with the concept model illustrated in *Figure 4 - 6*. imsmanifest XML structured as *Listing 4 - 4* is the main file of scorm standard. It specifies the constitution of certain material, i.e. the content packed into scorm package and the dependence among specifications and physical files as the matched pairs. In APM block, all the chosen slides

are bundled together in one scorm package rather than one slide per package. This would facilitate the interchangeability and interoperability between distinct LMS platforms.

```
<manifest>
  <organizations>
    <organization>
      <title>
      </title>
      <item>
        ⋮
      </item>
    </organization>
      ⋮
  </organizations>
  <resources>
    <resource>
      <file/>
    </resource>
      ⋮
  </resources>
</manifest>
```

Matched Pair

Listing 4 – 4 Structure of imsmanifest XML
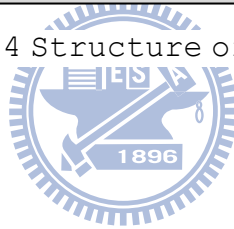
Chapter 5 Evaluation

The architecture and how we implemented LAM and APM modules have been described in Chapter 3 and Chapter 4 respectively. This chapter evaluates these two plugins. Section 5.1 compares our proposed modules with other existing systems and subchapter 5.2 shows the experiment result of LAM module.

5.1 Comparison

5.1.1 Annotation Comparison

I. Glover et al. stated the general requirements for educational web annotation systems[25] consisting of conceptual factors and technical factors which both have essential and desirable perspectives listed below. Conceptual factors are those being intrinsic to annotation where technical factors are those being related to the implementation of the conceptual factors.

- **Essential Factors**
    - Conceptual
        - (a) Text annotations
        - (b) Private annotations
    - Technical
        - (c) No additional software necessary
        - (d) Accessible
        - (e) Browser independent
        - (f) Maintains page integrity
- **Desirable Factors**
    - Conceptual
        - (a) Graphical annotations
        - (b) Linking annotations
        - (c) Shared annotations

(d) Annotation reports
- Technical
(e) Open architecture
(f) Non-commercial

Table 5 – 1 shows the satisfaction with these requirements of the annotating systems presented in [25] and LAM module. LAM meets all the essential requirements and misses two of the six desirable ones. Since LAM module merely offers textual annotation at present, these two kinds of annotation are not supported.

Table 5 – 1 Requirements for Educational Annotation Systems

| | Essential | | | | | | Desirable | | | | | |
| | Conceptual | | Technical | | | | Conceptual | | Technical | | | |
	a	b	c	d	e	f	a	b	c	d	e	f
LAM	✓	✓	✓	✓	✓	✓	–	–	✓	P	✓	✓
Annotea	✓	✓	P	P	P	✓	✓	✓	✓	–	✓	✓
Annoty	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Crit	✓	–	✓	✓	✓	✓	–	–	✓	–	✓	✓
e–Marked	✓	✓	✓	✓	✓	✓	–	✓	✓	–	–	–
Gibeo	✓	✓	✓	–	P	✓	✓	✓	✓	–	P	–
Third Voice	✓	✓	–	–	P	✓	–	–	✓	–	–	–
YAWAS	✓	✓	–	–	–	✓	–	–	P	–	✓	✓
eLAWS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 5 – 2 Annotation on Learning Materials

	Advantages	Disadvantages
LAM	•Integrated with LMS •Distinct annotation access level •Annotation on every page •Needless of devices / plugins	•Only textual annotation •Convert engine
Web–based annotation (Diigo)	•Numerous web pages •Tag and categorize	•Specific browser plugin •Not for pedagogic purpose
Device–driven annotation (PAM)	•Hand–written •Real–time discussion	•Specific device •Annotations are the same level
Online presentation (Slideshare)	•More file types •Tag and categorize •Voice annotation	•Annotation on whole material •No annotation management

Table 5 – 2 enumerates the benefits and drawbacks of LAM and other annotation skills on pedagogy characterized in Chapter 2. Our LAM module is the only application that integrates with LMS. The annotations can be made on specific pages rather than on whole material and no additional devices are needed.

5.1.2 Portfolio Comparison

Learning portfolios have been trended towards web-based. Most of current implementation schemes of the portfolios are web-oriented. We compare our portfolio module, APM, with the existing moodle portfolio plugins, Exabis ePortfolio and Simple Portfolio. APM portfolio is the only one plugin that integrates with moodle activities and supports offline viewing. Like the scheme utilized in Exabis ePortfolio, APM provides SCORM portfolio package as well. Our portfolio focuses on the course itself and the files of this course. So APM doesn't allow students to add personal files into their portfolio packages.
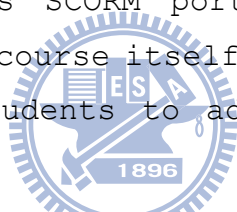
Table 5 – 3 Comparison among Existing Plugins

	APM	Exabis ePortfolio	Simple Portfolio
SCORM Package	Yes	Yes	No
Share Portfolio	No	Yes	No
Involving course files	Yes	No	Yes
Integrated with Moodle activities	Yes	No	No
Add personal files	No	Yes	Yes
Download portfolio	Yes	Yes	No
Viewing portfolio offline	Yes	No	No
Teacher View	No	No	Yes

5.2 Experimentation

An experiment about LAM has been conducted in a computer science course in our school, National Chiao Tung University, during the spring semester of 2009 to evaluate the actual effect of this module.

5.2.1 Experiment Method

There were total 98 undergraduate students took part in this experiment and these students were asked to read distinct articles and make annotations upon them using the LAM module on moodle LMS. Students were divided into several groups and each group had five students for the sake of collaborative and interactive learning. Every member in a group read, commented, and provided questions regarding the same article and submitted a brief report in the end of the experiment. This experiment lasted about five weeks. We design a questionnaire based on technology acceptance model (TAM) to investigate the effects of LAM.

5.2.2 Experiment Discussion

83 of the participated students answered the questionnaire and 13 of the responded questionnaires are considered as invalid since whole the questionnaire's answers are the same. All the statistics of this questionnaire are exhibited in Appendix D. 76% of these students whose questionnaires are valid thought information can be shared via the LAM module. 78% of them agreed that LAM is easy to learn and use and 63% of them agreed it is useful in tasks about annotation. 58% of students would like to utilize it once again.

The students had also proposed some feedbacks about LAM module along with the questionnaire. Their feedbacks focused on the following points:

- More user friendly interface

    LAM merely supports textual annotation at present. Students would like to possess more annotating skills such as highlight, search, and hand written. The deletion and modification of added annotation should be more convenient as well.

- Sticky note

The sticky notes provide an advantageous way to read both the personal and public annotations. But it would be a little chaos when there were too much sticky notes in one annotatable page. There should be certain mechanism to let the students filter the annotations.

■ Content / annotation selection

Because the teaching material is converted into image format via the utilization of convert engine, the material content can't be selected like the conventional operation on office software and so does the added annotation.

■ Hyperlink reference

There were some hyperlinks in the articles designated for this experiment. As the reason above, these links can't be referenced within the image. Besides, students also asked for the reference function on the sticky notes.

■ Notification for public annotation

Students thought information can be shared via public annotations. Though the annotations are synchronized while there are new ones being added, students still want to have some notification mechanism to be aware of new annotations.

Chapter 6 Conclusion and Future Works

6.1 Conclusion

The pedagogy has been trending toward e-learning 2.0 in recent years accompanying with the concept of WEB 2.0. This encourages the interaction and collaboration between learners and faculty and among peers. Though there are myriads of learning management systems being developed and are widely accepted by educators, there are no solutions currently to mend the gap between teaching materials and LMS. Those materials were merely uploaded to LMS by the teachers and downloaded by the students. There is no further utilization on the materials. LAM and APM modules are hence proposed in this thesis to cope with this critical issue.

LAM module provides an opportunity to make the interaction and collaboration be performed through the annotations attached on the learning materials. Learners can view the materials via moodle directly on line and mark up annotations about what they thought in their mind. The "Tab Bar" and the "Sticky Note" contribute a convenient manner to manage users' annotations. Students not only read the learning materials but also see what other students' opinions for certain portion of the matter.

APM module gives a way to pack students' learning actions carried out on moodle. It can be integrated with LAM or work properly by itself. Moodle **Activities** supplies an effective evidence to reveal how a student performed during the course processing. The annotation scorm package bridges distinct LMSs which are scorm-compliant. The interoperation between these LMSs becomes much easier.

6.2 Future Works

There are still certain draws in our proposed moodle modules. The outlook for our plugins involves the followings:

■ Applying these ideas to other LMSs.

To the best of our knowledge, there's no annotating function similar to ours built in existing LMSs. The concepts of our proposed plugins can be extended to other open source LMSs, such as ATutor.

■ Supporting different file types.

In the near future, we plan to extend the LAM module to support more material types. At present, LAM only handles PowerPoint slides. Despite it is the most popular file type to create teaching materials, there are still other material formats, especially PDF and HTML. These file types would be considered.

■ Other kind of slide transformation.

Another variety of transformation method would be required for LAM. LAM utilizes another convert engine, MS OFFICE COM, to perform the slide transformation. As discussed in the experimentation result, the slide content can't be selected from the converted slide image. MS OFFICE is, moreover, commercial software. This conflicts with non-commercial open source LMS.

■ More annotating manners.

LAM has merely textual annotating skill currently. More annotating fashions, like highlight the slide content, search for the inserted annotations, and content reference etc. would be provided.

■ Integrated with MAXML.

MAXML is a standard for interchangeable annotation proposed by our laboratory based on XML. The annotations added can be recorded following this standard to be interchanged more conveniently.

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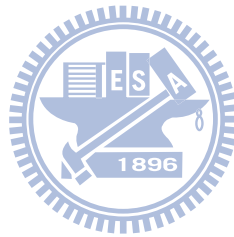
Appendix A User Guide for LAM

- ■ Turning on "Edition Mode" of Moodle site.
- ■ Selecting the course you want to install the LAM module.
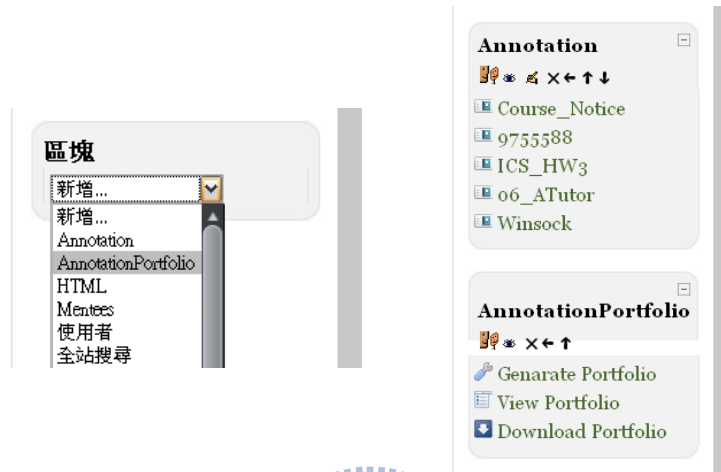- ■ Adding a new "Annotation" block from "Blocks".

Figure A – 1 Add LAM / APM Block

- ■ Performing the Convert/Delete operation for the materials want to be annotated by clicking the "Configuration" button in the Annotation block.
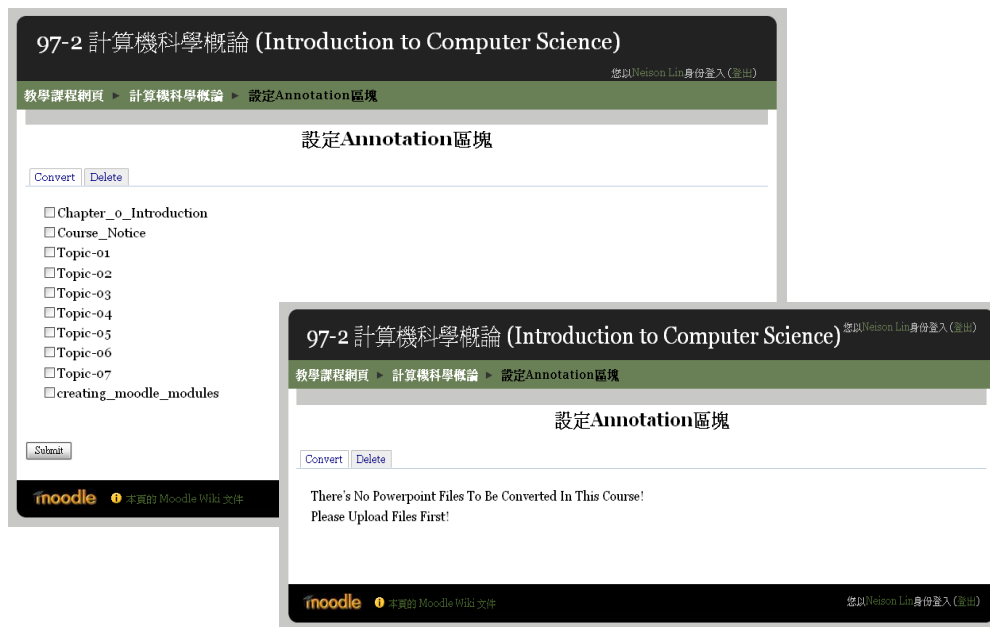
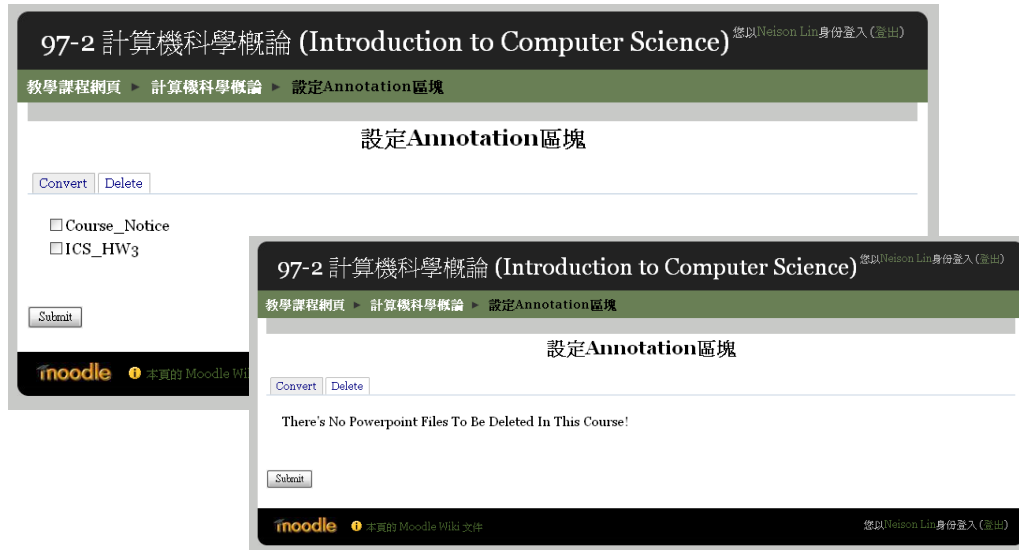

Figure A – 2 Configuration : Convert

Figure A – 3 Configuration : Delete

- There would be a hyper link for each converted lectures in the "Annotation" block.
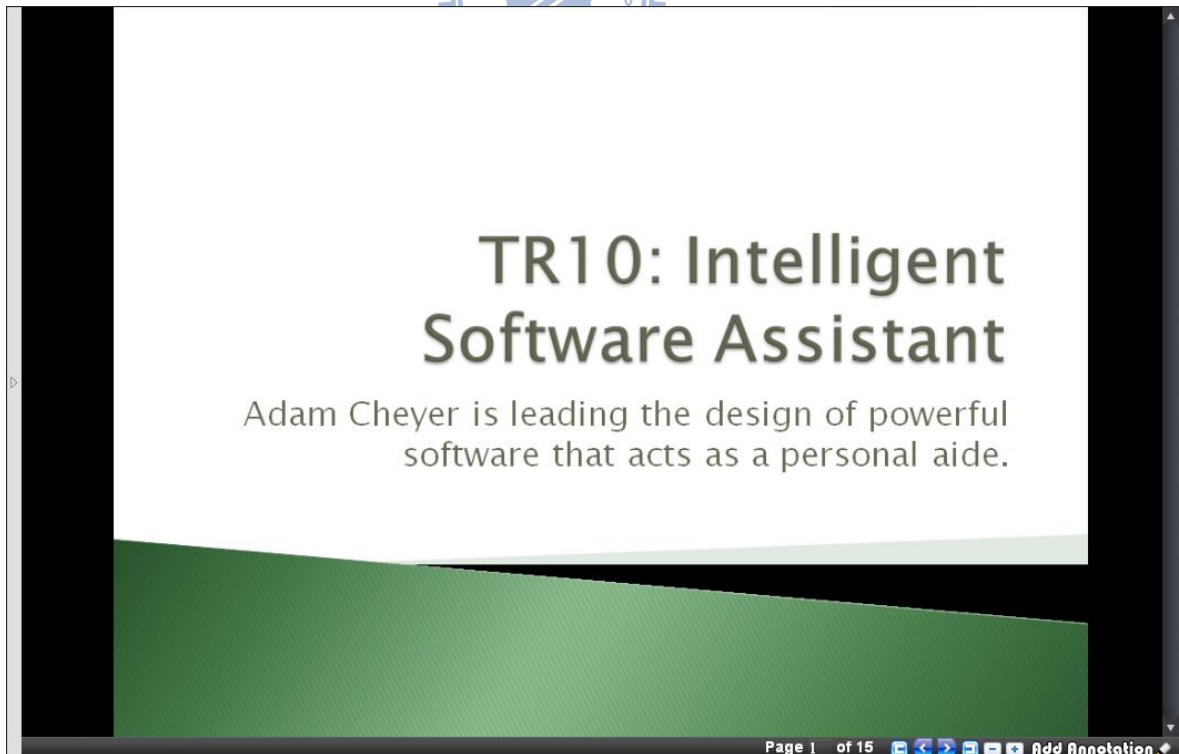- A corresponding annotatable page window will pop out for every slide.

Figure A – 4 New Annotatable Page Window

Table A - 1 Icons in Annotatable Page

Icon	Exposition	Icon	Exposition
Add Annotation	Add new annotation		Personal annotations
Delete	Delete the annotation		Readers
	First Page		Public annotations
	Last Page		Protect annotations
	Previous page		Access denied
	Next page		Personal sticky note
	Zoom in		Public sticky note
	Zoom out		

- User can see all his annotations in MyComment tab and goes to related page by click certain annotation.

- Students can know how many peers are currently viewing this slide in the "Readers" subtab and see all the public annotations made by other learners in the "Annotations" subtab.

- ForTeacher tab is designed for faculty. Only the protect annotations would be showed here.

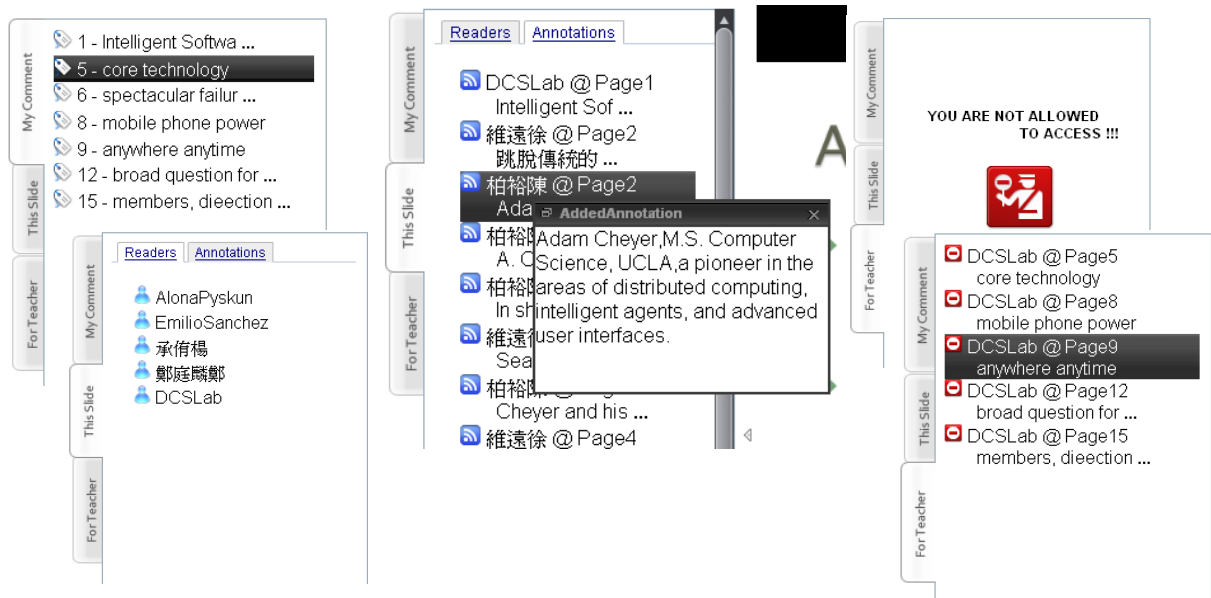- All the annotations showed in these tabs will be synchronized while there are new annotations being created.

Figure A – 5 Tab Bar

- A drag-and-drop based sticky note is attached onto the slide for each personal(Yellow Star)/public(Black Star) annotation.
- Tutors can comment students' protect/public annotations as well by right clicking the public sticky note.
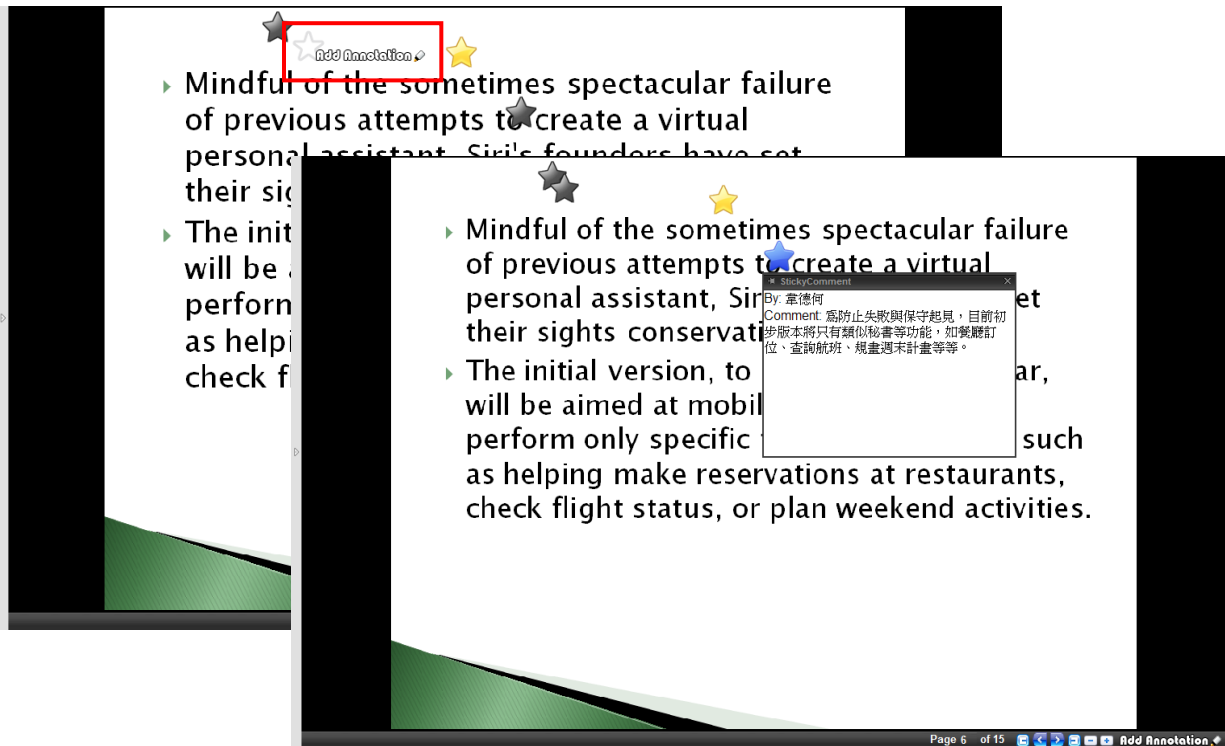
Figure A - 6 Sticky Note

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Appendix B User Guide for APM

■ Admins/faculty add the APM module like the way of LAM module.

■ Users generate their own portfolio by clicking "Generate Portfolio" in the "AnnotationPortfolio" block.

Figure B - 1 Generate Portfolio

■ Each category of the portfolio options has a corresponding folder in the generated portfolio catalogue.

■ The interchangeable scorm package is wrapped in annotation_scorm zip file.
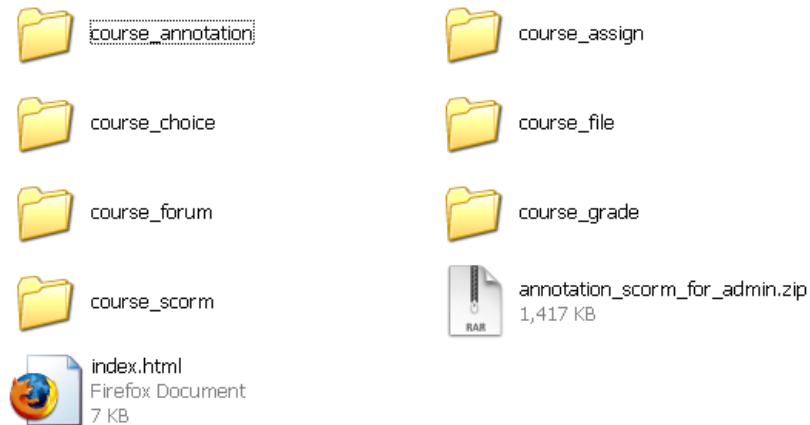
Figure B - 2 Inside the Portfolio Folder

■ The generated portfolio can be viewed online by clicking "View Portfolio" button.

Figure B - 3 View Portfolio Online

■ The portfolio can also viewed offline via the "index.html" file in the downloaded folder.

Portfolio For 管理 使用者
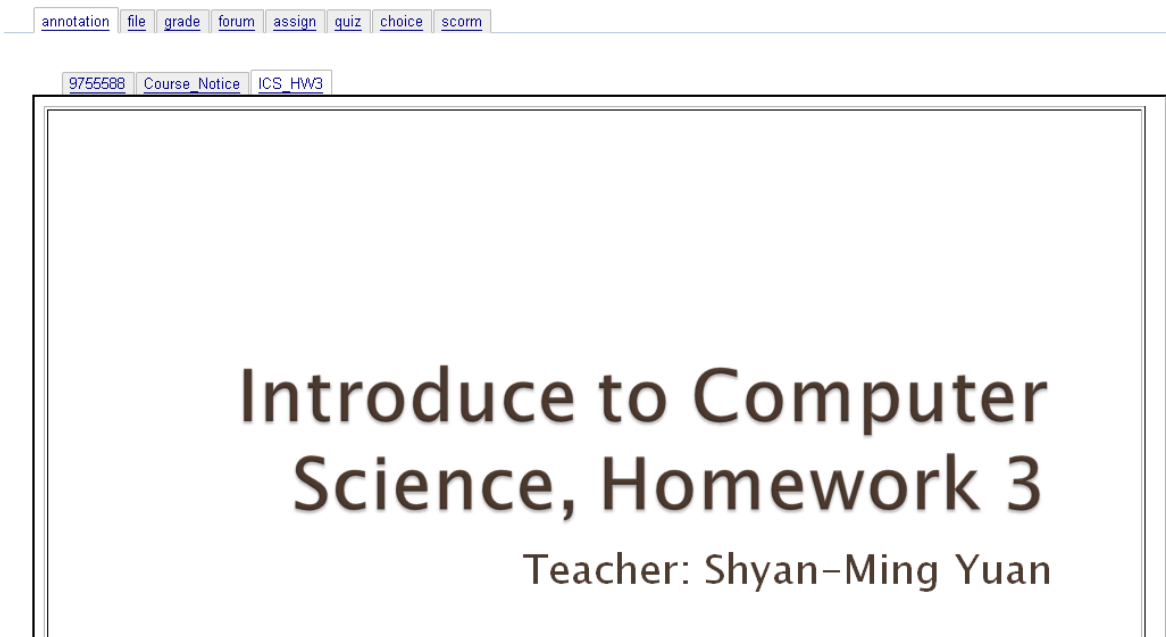
Figure B - 4 View Portfolio in Offline HTML

■ The annotation scorm package can be viewed in moodle LMS and other scorm-compliant LMS, such as ATutor.

Figure B – 5 Annotation Scorm View in Moodle

Figure B – 6 Annotation Scorm View in ATutor LMS

Appendix C Questionnaire for LAM

Questionnaire for Annotation Module in ICS Homework 3

1: Strongly Agree. 2: Agree. 3: No Opinion. 4: Disagree. 5: Strongly Disagree.

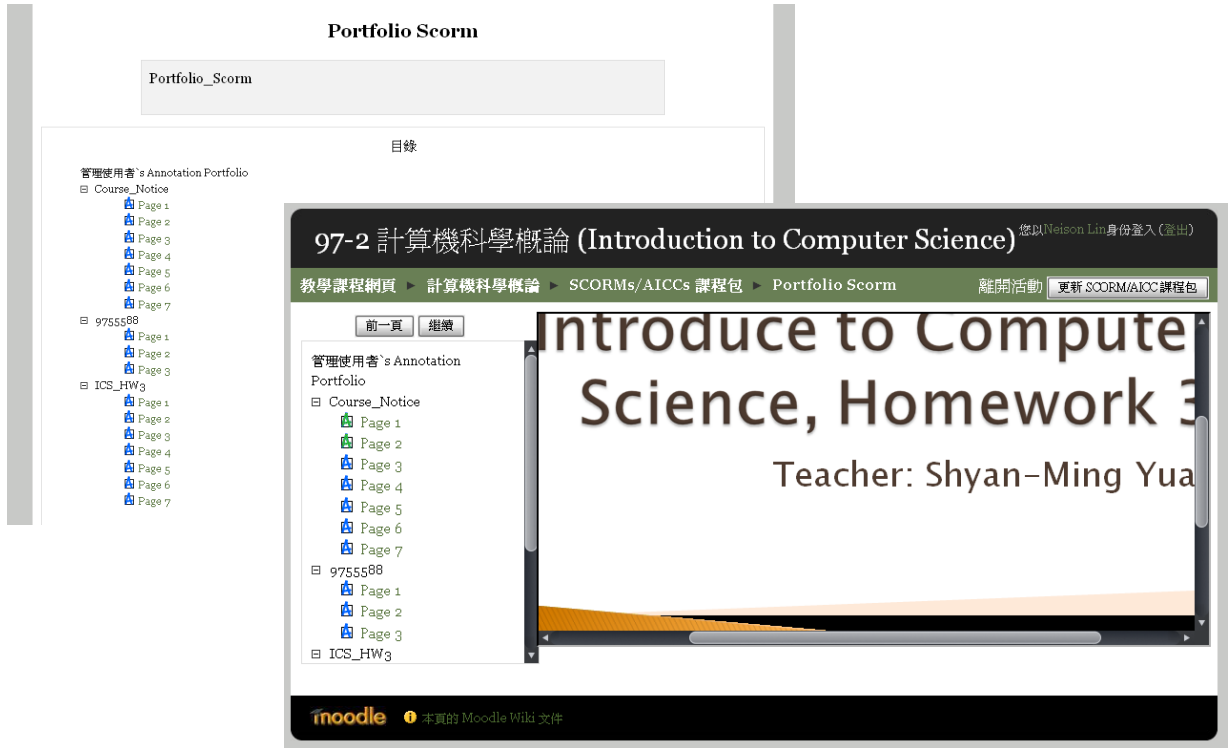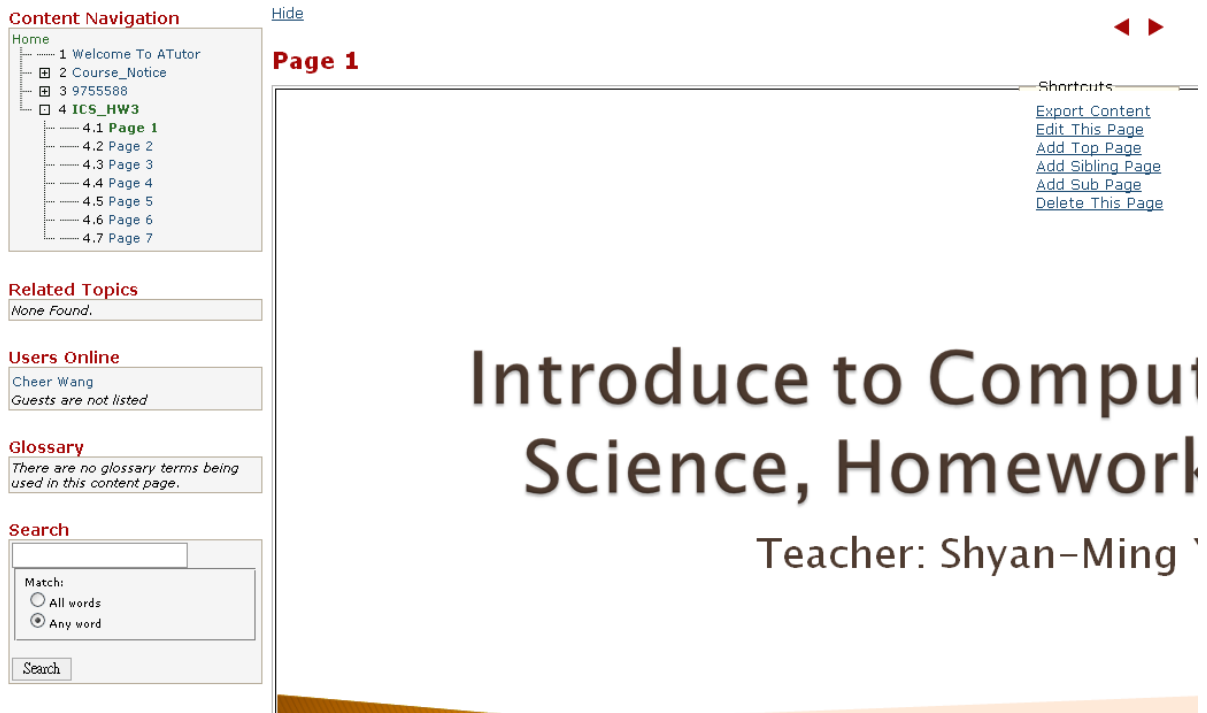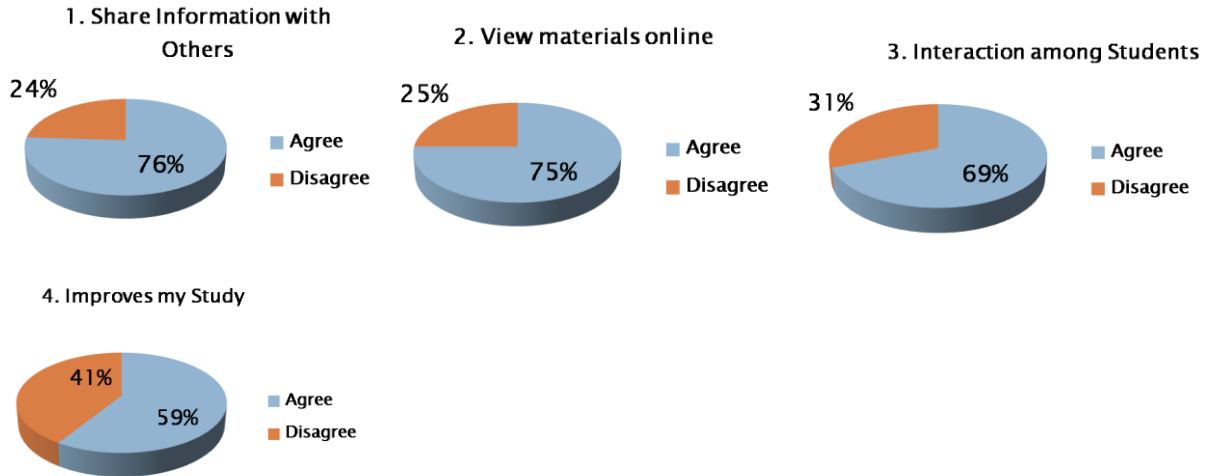|	1	2	3	4	5
System Characteristics					
1. This module makes it convenient to share information with others					
2. This module makes it convenient to view materials online					
3. This module improves the interaction among students					
4. This module improves my study					
Perceived Ease of Use					
5. Learning to use this module was easy					
6. The display pages within this module are easy to read					
7. I am familiar to terms used in this module.					
8. This module uses understandable graphics					
9. This module is easy to navigate					
10. This module makes me easy to recognize key information					
11. This module displays visually pleasing design					
12. I can easily interact with this module					
13. I would find this module easy to use					
Perceived Usefulness					
14. I use this module for acquiring information for HW3					
15. I use this module for information about my classmates					
16. Using this module enhances my learning effectiveness in HW3					
17. Using this module in HW3 does enable me to accomplish tasks more quickly					
18. Using this module makes me easier to do HW 3					
19. I found this module useful in tasks about annotation					
20. I would like to use this module once again for other annotation tasks					

I. How many times did you use the annotation module for homework 3?

II. Suggestions or Bug Reports for the annotation module, if any.

Appendix D Questionnaire Statistics

■ In "System Characteristics" Perspective:

1. Share Information with Others

24%
76%

- Agree
- Disagree

2. View materials online

25%
75%

- Agree
- Disagree

3. Interaction among Students

31%
69%

- Agree
- Disagree

4. Improves my Study

41%
59%

- Agree
- Disagree

■ In "Perceived Ease of Use" Perspective:

5. Learning to Use This Module

22%
78%

- Agree
- Disagree

6. Easy to Read

37%
63%

- Agree
- Disagree

7. Familiar to Tearms Used

35%
65%

- Agree
- Disagree

8. Understandable Graphics

16%
84%

- Agree
- Disagree

9. Easy to Navigate

29%
71%

- Agree
- Disagree

10. Recognize Key Information

43%
57%

- Agree
- Disagree

11. Visually Pleasing Design

41%
59%

- Agree
- Disagree

12. Interact with this Module

38%
62%

- Agree
- Disagree

13. Easy to Use

36%
64%

- Agree
- Disagree

■ **In "Perceived Usefulness" Perspective:**

14. Acquiring Information for HW3

15%

85%

- Agree
- Disagree

15. Information about My Classmates

49%

51%

- Agree
- Disagree

16. Enhances Learning Effectiveness

32%

68%

- Agree
- Disagree

17. Accomplish Tasks more Quickly

37%

63%

- Agree
- Disagree

18. Easier to Do HW 3

32%

68%

- Agree
- Disagree

19. Useful in tasks about Annotation

37%

63%

- Agree
- Disagree

20. Use this Module Once Again

42%

58%

- Agree
- Disagree