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Linking Learning Objects to eMM Metrics on Learning Delivery: A Case Study of IT Curriculum Development

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Abstract

This research is aimed to create the reusable learning objects (RLOs) and to evaluate the use of RLOs for designing the architecture of the obtained reusable learning objects under any Learning Management System (LMS) according to e-learning standard for measuring the reuse by e-Learning Maturity Model (eMM). The instruments employed are LMS in the type of Moodle v.1.3.1, ReLOAD Plug-in Program v.2.5.5, Protégé Program v.3.4.4 and spreadsheet of eMM v.2.3. The results obtained from the construction of RLO lessons revealed that it helps reducing time consumed for the lecturer in preparing teaching content. Finally, we obtain RLO tracking and eMM benchmark which means we can get RLO that can be tracked as well as a tool for evaluating the effectiveness of e-learning used in Thailand's institutes.

Keywords: Reusable learning objects, e-learning maturity model, e-learning life cycle, reusability

Introduction

It is obvious that e-learning has long played a crucial role in academic institutes. As such, this research is aimed at examining the academic institutes' implementation of e-learning systems for ensuring the learners' ability in obtaining complete knowledge both theoretical and practical under the concept that learning can be "anywhere and anytime" [1]. According to the standards of the e-learning systems used in education and relevant to this study, they are LOM (IEEE 1484.12.1, IEEE LTSC. IEEE LOM., 2008), and AICC CMI, and Global Learning Consortium's IMS Content Packaging [2].

Regarding the importance of e-learning, we all know that it is a powerful innovation that global academic institutes keep paying serious attention. Its most significant strength is that it possesses higher stability than the traditional method of constructing knowledge inside the classroom. Besides, when it is implemented, it provides the same standard to all systems launched. Also, it is very convenient for the management of knowledge, and audits. Above all, it automatically responds to the level of the individual learner's competence (On-demand availability)[3]. Despite the various benefits of e-learning mentioned, the challenging issues in dealing with the system are how to design a reusable course on e-learning with the highest cost-effectiveness and how to drive RLO tracking for the measurement of success.

In this paper, we intend to present the framework for development and management of the reusability of learning materials to cope with the issue mentioned above, and a case study of redesign for reuse of lessons and learning materials in two example curricula: Computer Science and Computers in Business.

Related work

A : Learning object

A learning object (LO) is a learning resource which can be the smallest unit of the learning process such as a letter, word, sentence, lesson, etc. It covers all types of learning materials; both digital and non-digital objects. Also, it can be

considered as the technology supporting learning process. An example of the collection of learning resources as the knowledge base which is further sent to the learners through different learning channels is presented in **Figure 1**.

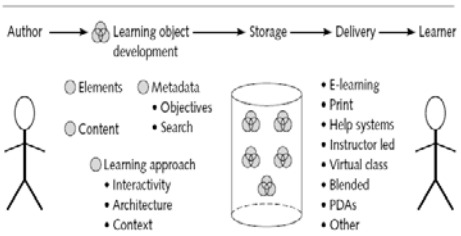

Figure 1 The learning object process**.**

LO is the multimedia content including a lesson, piece of the lesson, software for creating the lesson, tool for creating the lesson, and creators of the technology in facilitating the learning system [4]. The LO lesson is the part of the lesson that can be reused regularly. In this context, it means the existing resources such as code of program language, tools for envisaging the animation of program writing such as Java Applets, tools for creating logarithms, learning material in the form of MS-Word, MS-Powerpoint or Open Office documents, information of various kinds such as text, video, and flash [5].

Barritt *et al.* [6] and OASIS [7] have conducted many experiments in order to obtain the definition of the most comprehensible LO which can eventually be categorized through 4 basic standards, similar to that of SCORM or Cisco's RLOs, as presented in **Table 1**.

Table 1 Learning object terminology (Barritt *et al.* [6]; OASIS [7]).

Anything	Anything Digital	Anything for Learning	Specific Learning Environment
Asset	Content	Educational Object	Reusable Learning Object (RLO)
Component	Information Object	Learning Object	Unit of Learning
Learning Resource	Knowledge Object		Unit of Study
	Media Object		
	Raw Media Element		
	Reusable Information Object (RLO)		

As can be seen, **Table 1** presents the diversity of LOs according to their definition. **Figure 2** provides a clearer concept of the 4 categorizations.

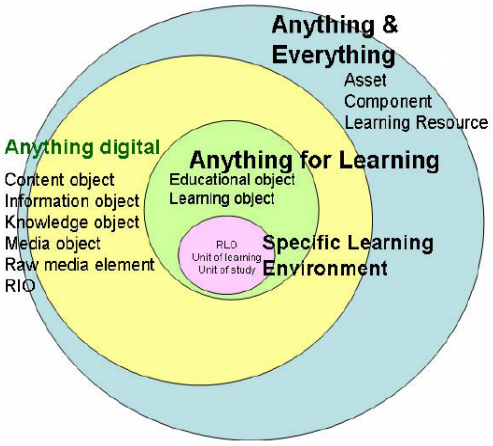

Figure 2 Terminology for learning objects [5].

B: Reusable learning objects (RLO)

RLOs are the pieces of the lesson: both in theoretical and practical patterns that can be reused [8]. RLO is the construction of the lesson through the collection of pieces in Reusable Information objects: RIO altogether. Also, it can be the pieces of teaching such as exercises and tests. For a clearer picture, RLO provides the objects for teaching activities while the components of the teaching and learning through a website is the

creation of content that can be reused. The reuse is considered as a good model which is the process of searching LO and adapting certain features as appropriate to the new content through the demands of the designer. It also allows the users possessing the appropriate competency to adapt the object or copy the information from the knowledge base, and even to add the information to the base as well. Though it is considered difficult for the system to be stored or familiar with such process, it allows the preparation of LOs for future usage. However, there are certain limitations to be considered such as the issue of control, ownership, and updating which have to be considered from the views of the producer and the users together.

RLOs or Shared Content Objects (SCO), according to the SCORM terminology, represents an alternative approach to content development. Learning objects are self-contained learning components that are stored and accessed independently. RLO is any digital resource that can be reused to support Web-based learning. Examples of RLOs may include live or streaming or prerecorded video or audio, a course module, animations, graphics, Web-based applications, Web pages, PDFs; Office documents; and other pieces that are aimed to deliver complete experiences, such as a lesson. From a pedagogical perspective, each RLO might play a specific role within an instructional design methodology. Learning objects can be re-assembled to create new courses or sequenced to form individual learning paths [9].

C : eLearning maturity model

The e-learning Maturity Model (eMM) was developed based on two complementary models: the Capability Maturity Model (CMM) and SPICE [10]. The work of Moazzam Baig, Sidra Basharat, and Manzile-Maqsood focuses on the development of a maturity framework for the higher educational sector that would enable education providers to improve quality of the existing educational processes and also aid the cost-effective development of value-added and practical processed that have been overlooked in the past [11].

Thus, eMM is the frame for the development and adjustment in order to improve the quality of e-learning by which the academic institutes can be evaluated and compared constantly which potentially leads to e-learning development and support. Tawsopar and Mekhabuncahkij [1] have presented a 3D approach to e-learning quality improvement. In the approach, the eMM is applied in the “Diagnosis” phase as an assessment tool for e-learning process improvement in an institutional context where the key elements necessary for improvement in e-learning activities are identified. The “Development” phase of the 3D approach concentrates on putting together improvement or change packages to target areas of deficiency. From a strategic point of view, the packages are translated into implementation plans in a short term, a mid-term, and a long term. In the “Delivery” phase of the approach, the main focus is the human resource and marketing efforts for implementing the changes at an operational level. The use of the 3D approach can be useful in monitoring the progress and recommendation of e-learning implementation and support in operational and strategic planning [12].

Conceptual framework

The conceptual framework developed in the research is to ensure that the construction and development of the curriculum on an e-learning system provides Learning Objects for the learners to choose according to their preferences, as well as a more cost-effective and flexible curriculum for implementation with some pedagogical purposes that are needed to overcome problems with the traditional learning method effectively [13]. The success of RLOs relies on the effectiveness of the existing database [1]. **Figure 3** illustrates the framework in which the RLO implementation life cycle is divided into six phases: Curriculum Management, Course Structure Mapping, RLO Creation, RLO Implementation, eMM Benchmarking, and RLO Tracking.

The key issues are:

(i) each RLO must be able to communicate with learning systems using some standardized method that does not depend on the system.

(ii) a sequencing system (usually forming a part of the LMS) defines the navigation rules for a learner to move between RLOs.

(iii) each RLO has a description that enables designers to search for and find the right RLO for the right job [14,15].

The purpose of this framework is to find an effective approach for auto-tracking RLOs in the e-learning system and automatic data preparation for eMM benchmarks in term of reusability.

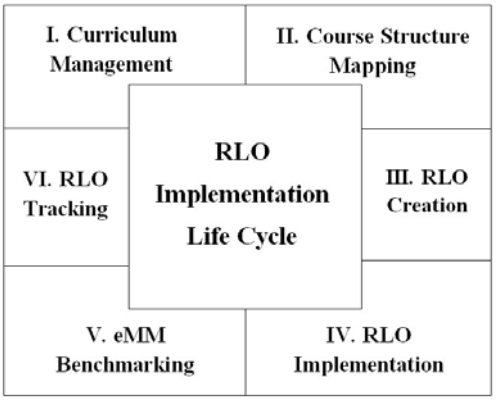

Figure 3 RLO implementation life cycle.

A : RLO implementation life cycle

Curriculum management: in order to design reusable learning materials among subjects in the same curriculum and subjects among different curricula, a working group must be established from relevant academic departments. The working group designs some criteria for selection and reusable lessons among subjects and curricula. For each specific subject, a department head and a focus group with 5 experts (i.e. lecturers and instructors) are assigned to process and monitor the production of RLOs and evaluate them.

Course structure mapping: This is the creation of the content mapping of the lessons with reusable materials. The mapping process needs approved reusable materials for a specific subject by the focus group established in curriculum management. The mapping process can be implemented using the software tool "Protégé".

RLO creation: The creation of RLO lessons is normally done on some LMS compliances with the standards of SCORM.

RLO implementation: This phase is the creation of RLOs from lesson plans and decisions on reusability made by the working group in the phase of curriculum management. The process of content packaging is needed to put RLOs together for later tracking and monitoring. In this phase, we use the software Reloaded and have developed some plug-in programs for the purpose of tracking and monitoring RLOs.

eMM benchmarks: In this phase the maturity on reusability is measured using some mathematical method and a checklist developed in the research. The maturity based on eMM is to reflect the level of e-learning development of an institute regarding the reusability of learning objects.

RLO tracking: This phase is aimed at measuring and evaluating the RLOs implemented in the previous phase.

Experimentation

As for the experiments on RLO implementation, we selected two curricula in Rattanabundit University: Bachelor of Computer Science and Bachelor of Computer in Business, run by the departments of Computer Science and Business Computer, respectively. For Phase I through Phase II in RLO implementation life cycle, the two departments agreed upon a number of reusable learning materials in two subjects: CS210 (Data Structure and Algorithms) and BC320 (Data Structure and Processing). For Phase III and Phase IV, the creation of RLOs were redesigned, and successfully packed and implemented on the university's LMS.

The collection of LOs implemented are diverse including digital, non-digital, and multimedia materials, for creating RLOs for each learning lesson on the LMS compliant Moodle software under the standards of SCORM2004 (see **Figure 4** is shown in Appendix I). We employed the ReLOAD Plug-in Program v.2.5.5 [16] which stored the content as packages (Content Package). Then, the packages of RLOs were processed to our core LMS for sharing the content between different LMS's (see **Figure 6** in Appendix I) using the ReLOAD Plug-in Program v.2.5.5. **Figure 5** in Appendix I shows an ontology for Course Structure Mapping prior to the creation of the RLO lessons using the Protégé program v.3.4.4 [17].

A content package consists of two main

components as follows. XML Document is the explanation of the content structure and learning resources in the package which is called the manifest file. The creation of the manifest must be done in accordance of IEEE XML Schema Binding for Learning Object Metadata Data Model. The number of physical files for learning such as sound, picture, web page, etc., as the learning resources were contained in the package.

A : RLO implementation

The implementation of the system experimented in this research uses Moodle software as the core system. The e-learning content prepared has been up and running since the first academic semester of 2011. **Figure 7** shows an example screen of RLO implementation.

Discussion and conclusion

The researchers have explored numerous eMM work and analyzed the eMM's original definition and checklist and searched for various crucial factors concerning the reuse of e-learning materials. The survey of experts, all five who were surveyed using 23 questions, they are further sub-classified into 92 items. Among these 92 items, there are 69 of them were responses with “agreed” by the experts (rated higher than 0.60). The result is shown in Appendix II. The checklist in Appendix II can be used to implement e-learning systems in the context of Thailand. In addition, in deciding the appropriateness of the system, the executives of the academic institutions can use the checklist to focus on the effectiveness and desire to increase the reusability of e-learning materials developed in this study. Finally, we obtain RLO tracking and eMM benchmark which means we can get RLO that can be tracked as well as a tool for evaluating the effectiveness of e-learning used in Thailand’s institutes.

However, the limitation of this work is due to the tool used, Protégé, in the creation of the relationships among learning lessons and subjects containing similar in contents as shown in **Figure 6** (Appendix I) .The software tool is somewhat hard to use especially for the teachers with limited experience. Hence, we recommend that there should be some customization or add-in software which makes it easier and more convenient for this specific purpose.

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APPENDIX I

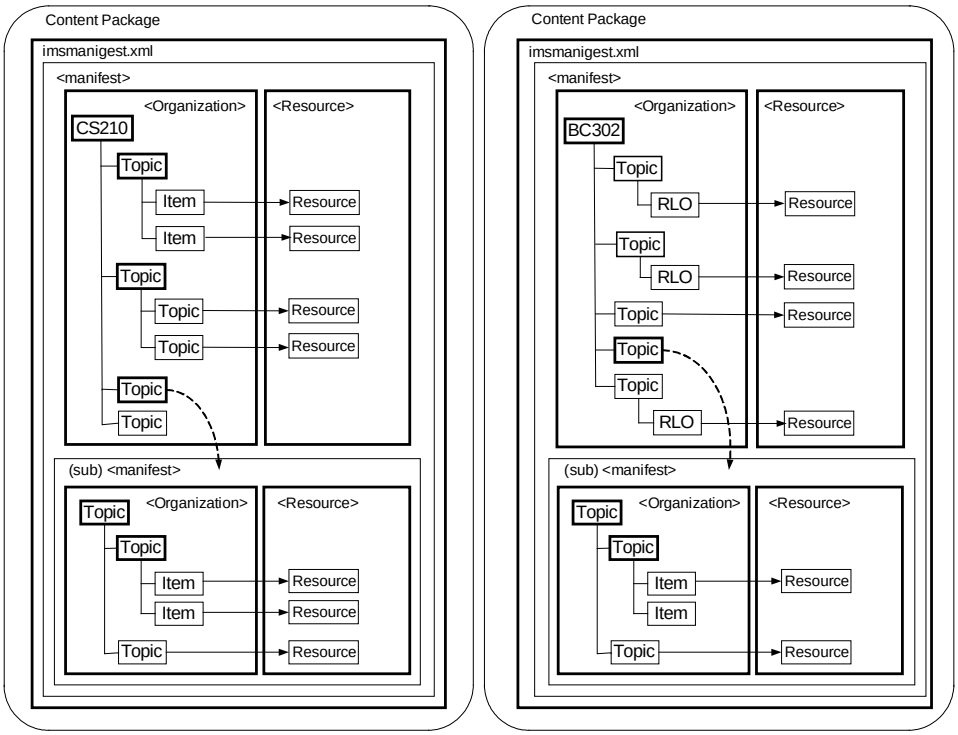

Figure 4 The creation of a RLO lesson by LMS Moodle system compliant with the standards of SCORM 2004 (v.1.3.1).

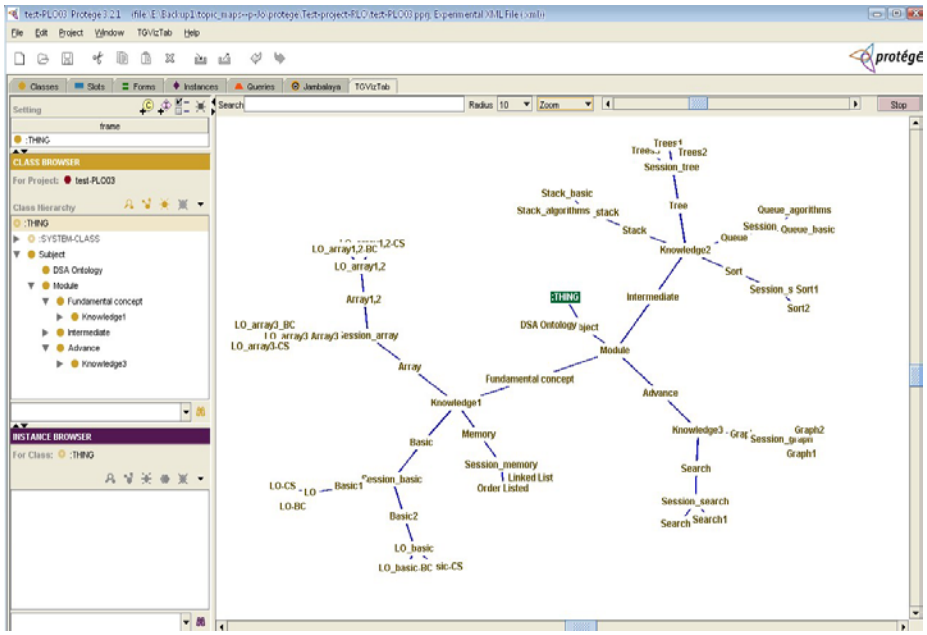

Figure 5 The creation of the relationship of example subjects and related lessons, on Protégé, which will share the reusable learning materials on LMS.

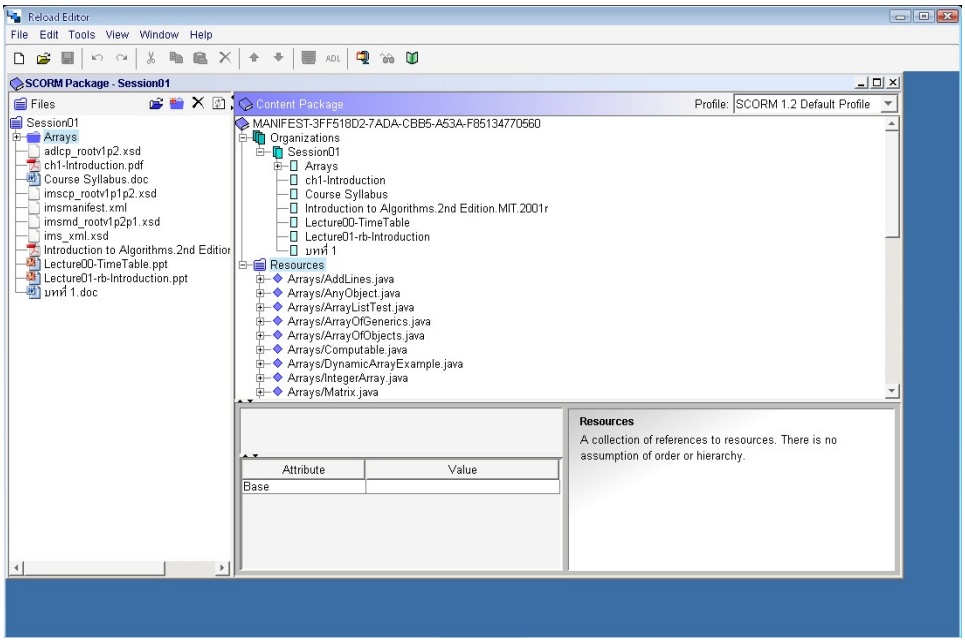

Figure 6 ReLOAD plug-in program for RLO. [16]

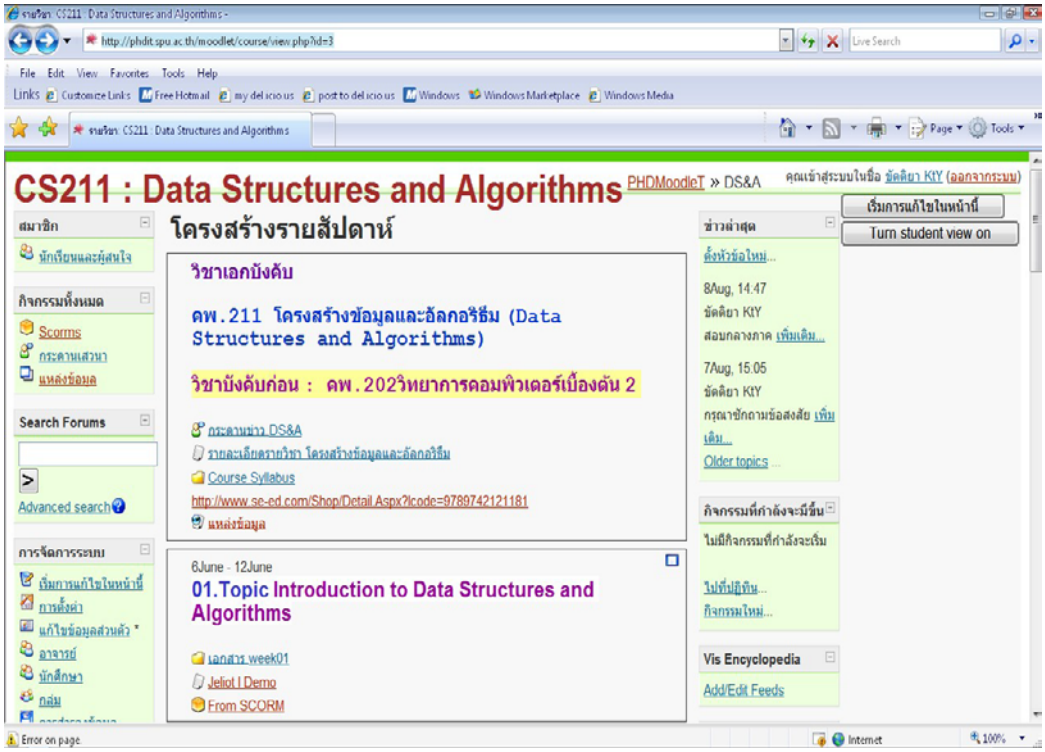

Figure 7 An example screen of the RLO implementation under Moodle.

APPENDIX II

Check List of Learning Materials Reuse

L2 Students are provided with mechanisms for interaction with teaching staff and other students
R.35 : Information on interaction between students and teaching staff guides the reuse of effective learning and teaching activities.

Criteria	Y	N
1. The University has a guide on how to create a Reusable Learning Object.		
2. The University has a guide on how to use e-Learning.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has a performance record of e-Learning system in all departments.		

L3 Students are provided with e-learning skill development
R.29 : Information on the use of learning activities that progressively build student capabilities guides the reuse of effective learning and teaching activities.

Criteria	Y	N
1. The University has a manual to guide learning activities that strengthens the capacities and skills of students.		
2. The Department has used article1 to gear the activity.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has used Reusable Learning Object 50%.		

L4 Students are provided with expected staff response times to student communications
R.30 : Information on interaction between students and teaching staff used to identify effective communication strategies for reuse.

Criteria	Y	N
1. The University has a guide for the interaction between students and teachers to identify effective communication strategies for the reuse		
2. The University has a guide on how to use e-Learning.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has the performance record of e-Learning system in all departments.		

L5 Students receive feedback on their performance within courses
R.29 : Information on feedback type and quality, and student satisfaction with feedback, used to identify effective feedback strategies for reuse.

Criteria	Y	N
1. The University has a guideline for students on how to express the opinions and preferences in order to identify effective strategies for Reuse.		
2. The University has a guide on how to use e-Learning.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has the performance record of e-Learning system in all departments.		

D7 E-learning resources are designed and managed to maximise reuse
R.3 : E–learning resources are packaged and stored for reuse.

Criteria	Y	N
1. The University has a guide on how to do RLO.		
2. The University has a guide on how to use e-Learning.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has the performance record of e-Learning system in all departments.		

R.11 : Incentives provided to teaching staff who reuse e-learning resources.

Criteria	Y	N
1. The University has a guideline on how to create the incentives for teachers and those who repeatedly used learning resources.		

2. The University has a guide on how to use e-Learning.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has the performance record of e-Learning system in all departments.		

R.15 : E-learning resources are designed to support reuse by students.

Criteria	Y	N
1. The University has a guide on how to design the learning materials for the learner so that they can replicate it efficiently.		
2. The University has a guide on how to use e-Learning.		
3. The Department has evaluated the effectiveness of e-Learning in all subjects.		
4. The University has performance record of e-Learning system in all departments.		

R.16 : Formal risk assessments of reuse and mitigation planning are required by e–learning reuse procedures.

Criteria	Y	N
1. The University has a guide on how to evaluate the risk of the Reuse Plan and modify processes the use of RLO's lessons as appropriate.		
2. The University has a guide on how to evaluate the risk of Reuse in article 1		
3. The Department has a guide for risk assessment as stated in article 1. for controlling purpose.		
4. The university has used a guide for risk assessment as stated in Article1 for controlling purposes at the rate of > 50 %.		

R.21 : Institutional policies encourage the reuse of e-learning resources.

Criteria	Y	N
1. The university has a policy to encourage and support the Reuse of Learning Resources.		
2. The university has a guide to help, encourage and support the Reuse of Learning Resources as stated in article 1		
3. Department has implemented the policy as stated in Article 1 and has the work record.		
4. The university has implemented the policy as stated in article 1 at the rate of > 50 %.		

R.25 : Institutional policies require that e-learning resources be created in a manner that supports reuse.

Criteria	Y	N
1. The University has the policy on the selection and implementation of e-Learning resources, and announces the criteria of resources to support Reuse.		
2. The Department has monitored the use of learning resources and identifies the reuse-able and non-reuse-able parts		
3. The Department has the tracked record in the use learning resources.		
4. The University has the tracked record in the use learning resources.		

R.30 : E–learning resources intended for reuse are tested and reviewed by staff and student users.

Criteria	Y	N
1. The University has the instructions on how to taste and review Reuse.		
2. The Department has used the instruction to test and review the Reuse as stated in article 1		
3. The Department has a work record in Article 2.		
4. The university has used a policy as stated in article 1 at the rate of > 50 %.		

R.31 : Feedback collected regularly from staff regarding the effectiveness of systems and procedures for encouraging and
supporting reuse of course resources.

Criteria	Y	N
1. The university has collected comments from teachers about the effectiveness of e-Learning and how to promote to use learning resources.		
2. The Department has implemented the results obtained from the article 1 to fix the defect.		
3. The Department has a work record in Article 2.		
4. The university has a performance record of the article 1		

R.32 : The extent to which resources are being reused is monitored regularly.

Criteria	Y	N
1. The university has monitored the use of learning resources consistently.		
2. The Department has monitored the use of learning resources consistently.		

3. The Department has a work record of Article 2.		
4. The university has the performance record in the article 1		

R.33 : The extent to which resources are being created for reuse is monitored regularly.

Criteria	Y	N
1. The University has examined the new learning resources for Reuse regularly.		
2. The Department has examined the new learning resources for Reuse regularly.		
3. The Department has a work record of Article 2.		
4. The university has a work record of Article 1.		

R.35 : Financial costs and benefits of reuse are regularly monitored.

Criteria	Y	N
1. The university has a guide on how to evaluate the costs and benefits to be received.		
2. The university has the mechanism to monitor and assess the cost of benefits to be received.		
3. The Department has assessed the costs and benefits to be received.		
4. The University has evaluated the costs and benefits to be received.		

R.36 : Formal e-learning reuse risk assessments and mitigation strategy reviews are undertaken with the results endorsed by
institutional leadership.

Criteria	Y	N
1. The university has the guide explaining the benefits and advantages of Reuse for towards a better quality of education.		
2. The Department has used the guide as stated in Article 1.		
3. The Department has a record of the guide implementation as stated in Article 1.		
4. The university has a record of the guide implementation as stated in Article 1.		

R.39 : Deployment and use of e-learning technologies is guided by information on its support of reuse.

Criteria	Y	N
1. The university has a guide on the selection of e-Learning technology, and suggested that there should be the information supporting the Reuse.		
2. The university has the guide to help the selection of e-Learning Technology as stated in Article 1.		
3. The Department has the guide in Article 1 and 2, with a record of use.		
4. The university has the guide in Article 1 and 2, with a record of use.		

R.40 : Information on the effectiveness of attempts to encourage reuse guides e-learning strategic planning.

Criteria	Y	N
1. The University has the policy to provide information on the Reuse to support organization for strategic planning.		
2. The Department has a policy stated in Article 1.		
3. The Department has a work record sated in Article 2.		
4. The university has implemented the policy in Article 1 and 2, with a work record.		

R.41 : Information on the extent of e-learning resource reuse guides e-learning initiative planning.

Criteria	Y	N
1. The University has the policy that provides information about the reusable learning resources and suggestions from planning and creating work.		
2. The Department has implemented a policy as stated in Article 1.		
3. The Department has a work record of Article 2.		
4. The university has implemented the policy in Article 1 and 2, with a work record.		

R.42 : Institutional risk assessments and mitigation strategies are regularly updated to reflect changing staff e-learning reuse support needs.

Criteria	Y	N
1. The University has the policy on risk assessment, strategic planning and dissemination of information which is provided through the regular basis in order to see the change of instructors and other support needs.		
2. The Department has implemented the policy as stated in Article 1.		
3. The Department has a work record of Article 2.		
4. The university has implemented the policy in Article 1 and 2, with a work record.		

O1 Formal criteria guide the allocation of resources for e-learning design, development and delivery

R.32 : Applications for e-learning resource allocation are analysed for reuse.

Criteria	Y	N
1. The University has guidelines for the allocation of learning resources to develop the design and implementation.		
2. The Department has a guideline in Article 1.		
3. The Department has a work record of Article 2.		
4. The university has implemented the guidelines in Article 1 and 2, with a record of use.		

O5 E-learning initiatives are guided by explicit development plans

R.29 : E–learning initiative plans are analysed for potential reuse.

Criteria	Y	N
1. The University has a policy to evaluate every project with a new initiative.		
2. The Department has a policy in Article 1.		
3. The Department has a work record in Article 2.		
4. The university has implemented the policy in Article 1 and 2, with a record of use.		

O9 E-learning initiatives are guided by institutional strategies and operational plans

R.35 : Information on the outcomes of e-learning initiatives guides reuse of e-learning strategic planning and management documents.

Criteria	Y	N
1. The University has a policy that every project must strictly follows the strategy and action plan of the institution.		
2. The Department has implemented the policy in Article 1.		
3. The Department has a work record of Article 2.		
4. The university has implemented the policy in Article 1 and 2, with a work record.		