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Identification and Prioritization of Variables Influencing the Cost of Learning Content Development

A thesis submitted in fulfilment of the
requirements for the award of the degree

Master of Engineering (Research)

From

University of Wollongong



By

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MIT (UOW), BCS (NAFU)

School of Electrical, Computer & Telecommunications Engineering

November 2009

CERTIFICATION

I, Zhengui Wu, declare that this thesis, submitted in fulfilment of the requirements for the award of Masters of Engineering (Research), in the Faculty of Informatics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Zhengui Wu

30 November 2009

ABSTRACT

A dominant factor in cost analyses of e-Learning programs at tertiary education institutions is the measurement of direct and indirect costs associated with digital learning content, or in brief, learning content. In broad terms, over 60% of total e-Learning costs are related to design, development, publication and evaluation of learning content. The inclusion of new and emerging concepts and technologies including Learning Objects (LOs) and Learning Content Management Systems (LCMSs) into e-Learning programs at universities has opened up new opportunities and increased the complexity of learning content cost analyses.

This thesis constructs a model that offers a minimized cost for the design, development and publication of learning content in a typical e-Learning program. Steps towards building the target model include the investigation of factors that affect learning content development, identification and prioritization of variables influencing the development cost, discussion of the relationships between identified variables and the process of learning content development, and analyses of two extreme cost structures. Finally, by assigning relevant variables in the available cost structure, a cost-effective model that covers the three main processes for design, development and publication of learning content is constructed.

The cost-effective model introduced in this thesis covers not only the main subject notes but also content materials that are widely used in e-Learning programs. The proposed model takes into account subject notes and other materials which include quizzes, tutorial questions, critical thinking tasks and assignments as Learning Objects. In addition, based on this model, an experimental platform is designed and implemented to support the practical aspects of the proposed model noting its limitations and constraints. The experimental platform allows for the implementation of a simple case study for verification of development strategies adopted in the proposed cost-effective model. The reusability of Learning Objects used in the case study, and standards compliance of the resultant learning packages with different e-Learning platforms are also tested and documented.

As an efficient and effective method of enhancing and facilitating students' learning, e-Learning has obtained a wider acceptance among higher education institutions. The concept of Learning Objects and underlying models and technologies, including the proposed cost model, represent a cost-effective approach for accelerating the design, development and publication of learning content that can be highlighted in the development of e-Learning programs worldwide.

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ABBREVIATIONS

ADL	Advanced Distributed Learning
ADSL	Asymmetrical Digital Subscriber Line
AICC	Aviation Industry CBT Committee
API	Application Programming Interface
ATRC	Adaptive Technology Resource Center
CAM	Content Aggregation Model
CD	Compact Disc
DNS	Domain Name System
DoD	Department of Defense
DOOR	Digital Open Object Repository
DSL	Digital Subscriber Line
DVD	Digital Video Disc
eXe	elearning XHTML editor
FAQs	Frequently Asked Questions
ICT	Information and Communication Technology
IEEE/LTSC	Learning Technology Standards Committee of the Institute of Electrical and Electronic Engineers
ISD	Instructional System Design
ISP	Internet Service Provider
ITRC	Iranian Telecommunication Research Center
LCMS	Learning Content Management System
LOs	Learning Objects
LOM	Learning Object Metadata
LMS	Learning Management System
LOR	Learning Object Repository
OSS	Open Source Software
QUIS	Quality, Interoperability and Standards
QTI	Question & Test Interoperability Specification
RLOs	Reusable Learning Objects
ROI	Return On Investment
RTM	Run-Time Environment
SCORM	Sharable Content Object Reference Model

ABBREVIATIONS

SCOs	Sharable Content Objects
Sloan-C	Sloan Consortium
SN	Sequencing & Navigation
VLE	Virtual Learning Environment
WBT	Web-Based Training
WWW	World Wide Web

CHAPTER 1. INTRODUCTION

Over the past five years, investments have significantly increased in the global e-Learning market. According to a conservative estimate from e-Learning global strategic business report, the U.S. e-Learning market was worth \$17.5 billion in 2007; further, it is expected that the use of e-Learning worldwide will continue to grow and surpass \$52.6 billion by 2010 [1]. Electronic learning or e-Learning is a general term used to refer to computer-delivered training and education [2]. As the most successful commercial medium of e-Learning, the common understanding of e-Learning also relates to Web-Based Training (WBT) [3]. By using the Internet as a delivery medium to facilitate and enhance learning, WBT has been widely adopted by many higher education institutions.

The statistics from a Sloan Consortium (Sloan-C) survey summarized that there were more than 2500 colleges and universities who offered online learning in the U.S. in 2006, the report also showed that nearly 3.5 million American students were enrolled in at least one online course in the fall of 2006, which is almost a 10% increase of total enrolments compared to the previous year [4]. The growth of the World Wide Web (WWW) and the development of computer technologies have allowed students to access these online courses around the globe, 24 hours a day, 7 days a week.

1.1 Overview of Digital Learning Content

Because learning can be undertaken anytime, anywhere and at any pace, the benefits of WBT are obvious. The biggest benefit of WBT is that it saves substantial learning costs by replacing instructor-led training with digital content delivery [5]. Therefore, digital content is the most important component of any WBT initiative. Meanwhile, along with the growth of the e-Learning market, a dramatic growth in demand for high quality learning content has emerged. However, creating a successful e-Learning course is heavily dependent on the quality of the learning content and hence many organizations and companies have invested a great deal of time and energy to develop digital learning content.

Digital learning content is essentially electronic information that is used for teaching and learning, viewed on a computer or similar device [6]. It can be presented as text,

images, audio, video, animations or a combination of these. Since computer technologies offer robust hardware and flexible software, development of digital learning content has become faster, cheaper and more effective. However, design, development and publication of learning content still accounts for up to 60% of total e-Learning costs [7]. Therefore, reducing the development cost of e-Learning and producing cost-effective learning content is becoming a new challenge for tertiary education institutions. The concept of Learning Objects (LOs) has indicated a potential to solve this issue [8]: Packaging high quality learning materials as LOs, making them sharable and reusable in an Internet accessible Learning Object Repository (LOR), and publishing them through the Learning Management System (LMS) are cost-effective approaches [9].

1.2 Research Objective and Approach

Currently, due to the demands on the digital learning content in higher education institutions, content authors are seeking cost-effective ways to enable rapid production and publication of digital learning content. Aiming to solve this issue, research efforts presented in this thesis can be well explained in two main categories: firstly, the identification and prioritization of variables influencing the cost of learning content development; secondly, the construction of a cost-effective model that can be used to facilitate the design, development and publication of learning content.



Figure 1.1: Factors Affecting Learning Content Development [10]

Identification of variables influencing the cost of learning content development is based on a research report published by the Iranian Telecommunication Research Center (ITRC) [10]. Ten essential factors that affect learning content development, as specified in the research report, have been investigated [10] (see Figure 1.1).

During the investigation in [10], design, development and publication are considered as the three processes of learning content development. Based on common practices, in this thesis relationships between rest factors and these three processes are found, and the impacts of rest factors on these content development processes are discussed. Through the discussion in Section 3.2 of this thesis, 12 variables that directly or indirectly influence the cost of learning content development are identified. These variables are known as:

- | | |
|--------------------------|----------------------------|
| 1. Required Resources | 2. Pedagogy |
| 3. Educational Model | 4. Bandwidth and Access |
| 5. Standards | 6. Production Technologies |
| 7. Modularity | 8. Interaction |
| 9. Copyright | 10. Quality |
| 11. E-Learning Platforms | 12. Evaluation |

To prioritize the identified variables, flowcharts of content design, development and publication processes with the identified variables have been drawn in Chapter 4 to describe the relationships between these variables and each step of the learning content development process. Based on the extent of each variable's impact on the process of learning content development, identified variables are thus prioritized.

The methodology adapted for the target model construction, using processes introduced in the early stage of the research work, is purely based on the introduction of two extreme scenarios: A high and low cost structure. The refined and prioritized variables included in the target model directly result from the drawing of rational and logical links between elements of these two scenarios.

Selecting development strategies for given variables in the target cost-effective model from either the high or low cost structure are based on the concept of cost-effectiveness. According to Quality, Interoperability and Standards in e-Learning (QUIS), which is a

project that has been carried out with the support of the European community, a cost-effective strategy can be described as [11]:

- *Less costly and at least as effective;*
- *More costly and more effective with an added efficacy that is worth paying an additional price for;*
- *Less effective and less costly, where the additional cost of the alternative is too high for the additional benefits provided;*

Therefore, constructing this cost-effective model does not simply adopt the cheapest strategy.

Moreover, development strategies are attached to those variables that do not match the suitable strategies in both structures. The cost-effective model proposed in this thesis covers three stages of learning content development: Learning content planning and design, development, and publication and evaluation. Figure 1.2 shows the methodology adopted in this thesis for the construction of a cost-effective model.

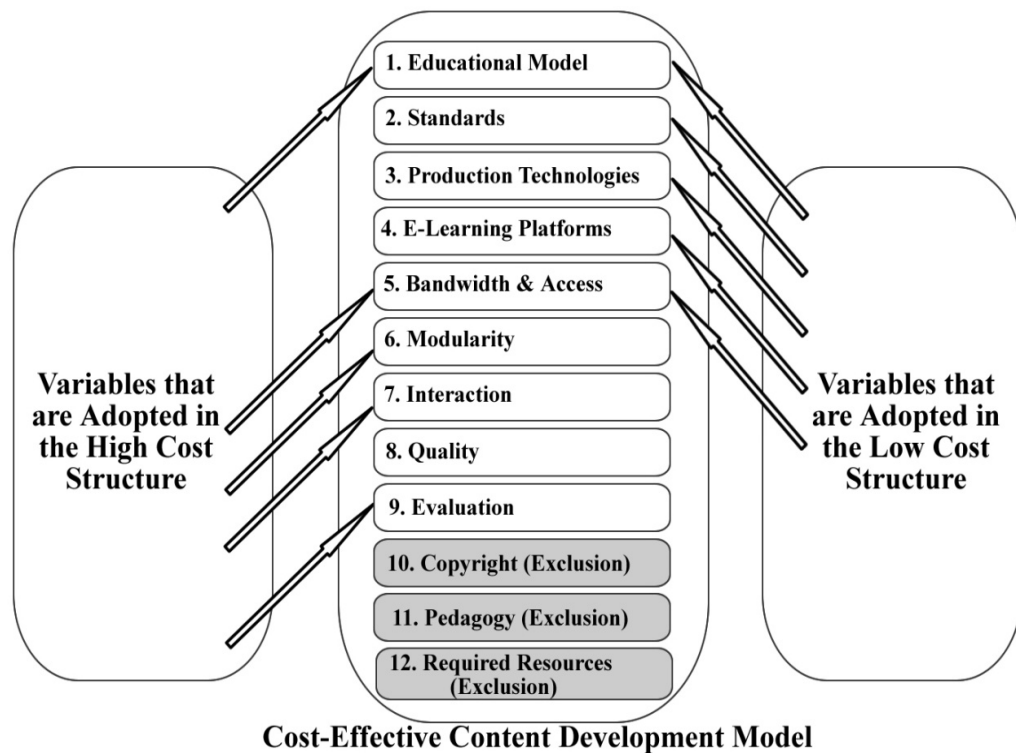


Figure 1.2: The Methodology Adopted for the Construction of a Cost-effective Model

By assigning suitable development strategies to variables in each process, a cost-effective content development model that helps the design, development and publication of learning content is constructed and proposed in this thesis. Following the development strategies within the proposed model, the content development process can be simplified, whilst created learning content complies with e-Learning standards and has assured quality. Moreover, the created learning content is packaged in Sharable Content Object Reference Model (SCORM)-compliant LOs to make the content reusable and easy to update.

To support the practical aspects of the target cost-effective model subject to limitations and constraints, an experimental platform consisting of a range of hardware and software is designed and implemented in this thesis. A case study which converts existing course materials into LOs is evaluated on this platform to offer extra practical information on the cost-effective model, and provides evaluation results about the standards compliance of the proposed platform.

However, some identified variables contain parameters that are unpredictable and uncontrollable, hence the costs of these parameters are hard to detect and estimate. Thus, 3 variables and 8 parameters have been excluded from the formulation of the cost-effective model and are shown in Table 1.1.

Variables	Parameters
Production Technologies	1. Cost of client-side hardware 2. Cost of client-side software
e-Learning Platforms	3. Cost of e-Learning hardware platform
Bandwidth & Access	4. Cost of broadband connection 5. Cost of access technologies
Copyright (exclusion)	6. Cost of obtaining copyright permission
Pedagogy (exclusion)	7. Cost of design learning theories and models
Required Resources (exclusion)	8. Cost of hiring personnel and associated resources

Table 1.1: Variables and Parameters Excluded from the Formulation of Cost-effective Model

1.3 Thesis Outline

Chapter 2 presents a literature review on the concept of LOs and its underlying technologies. To understand the concept of LOs, the definitions of the term LOs are thus reviewed. Subsequently, related technologies such as standards, specifications, and e-Learning systems are respectively introduced. At the end of this chapter, an overview of learning content development is provided, which summarizes the common learning content development models and the classification of the e-Learning development projects.

Focusing on developing learning content as LOs, Chapter 3 investigates essential factors that affect learning content development. Through analyzing the process of learning content development, variables influencing the cost of learning content development are identified based on these factors. The impacts of the identified variables on the development cost are discussed to determine the possible development strategies of these variables.

Once the variables are identified, it is useful to prioritize them for minimization of the development cost. To prioritize identified variables, 3 flowcharts of development stages with identified variables have been drawn in Chapter 4 to indicate the relationships between these variables and learning content design, development and publication processes. Subsequently, identified variables are prioritized according to the extent of each variable's impact on the process of learning content development.

Following the prioritization of variables, a cost-effective model has been constructed in Chapter 5 utilizing the identified variables. To obtain the target model, controllable variables are extracted from the identified variables. Development strategies for given variables are selected from either the high or low cost structure to build the model. In the cost-effective model, Open Source Software (OSS) packages are widely adopted in order to reduce the development cost and thus help the content developers to create cost-effective learning content.

Chapter 6 offers an experimental platform that is designed and implemented to support the development strategies adopted in the proposed cost-effective model. This experimental platform intends to provide more information about the proposed

development model in a practical environment. By converting sample course materials into LOs, a case study along the entire learning content development process has been evaluated on the platform. An assessment which focuses on the reusability of the created learning content and the standard compliances of e-Learning platforms is also presented in this chapter.

Chapter 7 summarizes the overall tasks accomplished during this thesis work and provides recommendations for future investigations.

CHAPTER 2. LITERATURE REVIEW

E-Learning courses usually consist of many learning units and instructional designers currently design learning units as individual Learning Objects (LOs) to enhance the reusability of the learning content. The concept of LOs represents a new way to produce and deliver digital learning content. The attractive features of LOs, which include reusability, interoperability, durability and accessibility, have indicated that LOs have the potential to aid the acceleration of the learning content development. This chapter provides a literature review of the concept of LOs and its underlying technologies.

This chapter starts with the definitions of the term LOs and introduces the related standards. As the most popular standard in WBT, the Sharable Content Object Reference Model (SCORM) is further discussed. Subsequently, typical e-Learning systems that support content and learning management in e-Learning are introduced. Lastly, a summary that describes the common learning content development model and the classification of e-Learning development projects is presented to provide basic information about learning content development in WBT.

2.1 The Concept of Learning Objects

As a new concept in digital learning content, the LOs have attracted broad attention within the e-Learning industry. To define a LO, many definitions have been proposed, and according to the Learning Technology Standards Committee of the Institute of Electrical and Electronic Engineers (IEEE/LTSC), a LO can be defined as [12]:

"Any entity, digital or non-digital, that may be used for learning, education or training".

David Wiley narrowed the IEEE's definition with emphasis on the reusability of LOs, more specifically describing a LO as [13]:

"Any digital resource that can be reused to support learning".

Along with the development of LO technologies, further refinements to the definition have been added. In 2007, Chiappe provided a description of LOs as [14]:

"A digital self-contained and reusable entity, with a clear educational purpose, with at least three internal and editable components: content, learning activities and elements of context. The LOs must have an external structure of information to facilitate their identification, storage and retrieval: metadata".

In addition to defining a LO, several researchers have also focused on the features of LOs. A British Centre for Excellence in Teaching and Learning in Reusable Learning Objects (RLO-CETL) defined Reusable Learning Objects (RLOs) as [15]:

"Web-based interactive chunks of e-Learning designed to explain a stand-alone learning objective".

In 2003, Rehak and Mason provided a widely accepted definition of a RLO [16]:

"A digitized entity which can be used, reused or referenced during technology supported learning".

Figure 2.1 illustrates the building of an e-Learning course by aggregating RLOs.

Please see print copy for image

Figure 2.1: Building e-Learning Course by Aggregating RLOs [17]

Normally, traditional digital learning content is developed for a complete course. It is difficult to reuse created learning content in different courses or modify the content to keep them updated. However, the design and development of learning content as RLOs can satisfy the needs for both content reuse and update. According to its definitions,

RLOs can be treated as small chunks of learning content that are designed to explain a specific learning objective. Each chunk contains typically 10-15 minutes of learning materials with concentrated learning experiences. In this case, the RLO has been broken down to a lower granular level: Larger learning units at a higher level can be formed by aggregating these self-contained RLOs.

Before considering the construction of a LO, some technologies related to a LO should be mentioned. As the key components of e-Learning infrastructure, these technologies not only facilitate the adoption of LOs, but also enable the multiple features of LOs. In fact, these technologies are widely known and addressed in standards and e-Learning systems [18].

2.2 E-Learning Standards

E-Learning standards are generally developed to be adopted in the system design and implementation processes to achieve the goals of interoperability, adaptability, accessibility and reusability [18]. Many organizations have invested a great deal of time and energy into develop e-Learning standards. The main contributors to the e-Learning standards are the IEEE/LTSC, IMS Global Learning Consortium, Aviation Industry CBT Committee (AICC), and Advanced Distributed Learning (ADL) initiatives [2].

The standards and specifications involved with learning content development include:

- Sharable Content Object Reference Model (SCORM) [19]
- The IMS Content Packaging Specification [20]
- The IMS Simple Sequencing Specification [21]
- The IMS Learning Resource Meta-Data Specification [22]
- The IMS Question & Test Interoperability Specification (QTI) [23]
- IEEE/LTSC Learning Object Metadata (LOM) Standard [12]

2.2.1 Sharable Content Object Reference Model (SCORM)

The Advanced Distributed Learning (ADL) initiative is a United States Department of Defense (DoD) project, sponsored by the US Federal Government [24]. SCORM is an important contribution to web-based e-Learning by ADL. As the most popular learning content component model, SCORM was developed to enable the creation of high-quality reusable learning content. By ensuring reusability, accessibility, durability,

adaptability, affordability and interoperability of learning content, SCORM has promoted the standardization of e-Learning content [19].

SCORM is a collection of specifications and standards. Rather than creating a new standard, SCORM combines different standards and specifications from other organizations such as the IEEE, IMS and AICC. ADL dramatically described SCORM as a bookshelf, where adopted standards and specifications can be considered and viewed as separate books [19]. In SCORM 2004 3rd Edition [19], these technical books were grouped and collected by three main topics: Content Aggregation Model (CAM), Run-Time Environment (RTM) and Sequencing & Navigation (SN) (Figure 2.2).

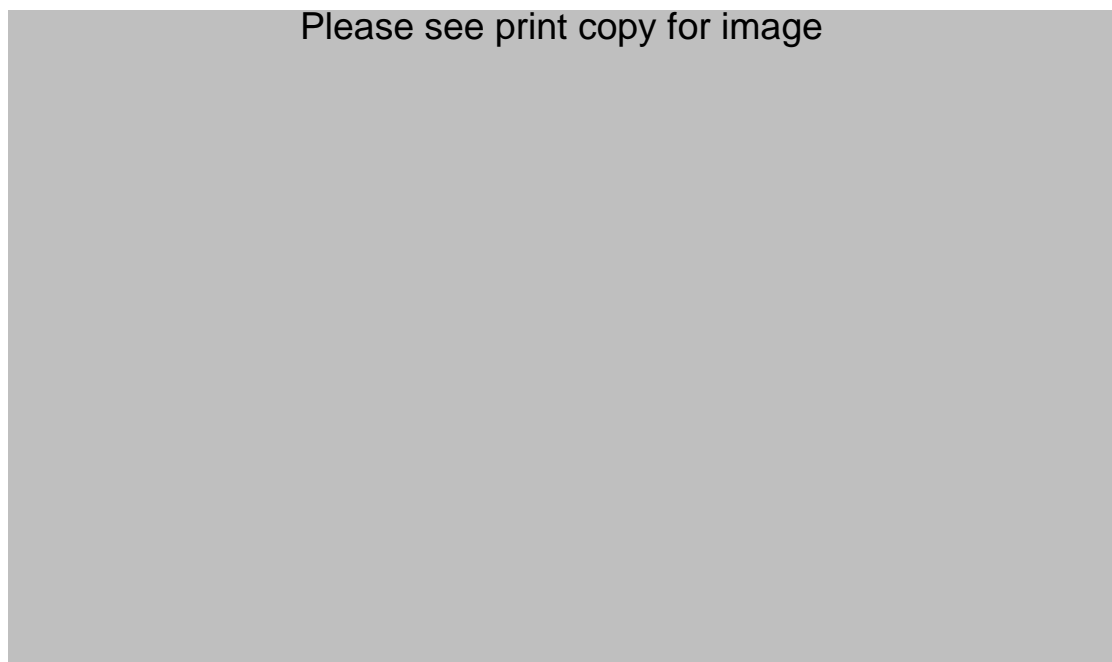


Figure 2.2: SCORM Bookshelf [19]

- The SCORM CAM defines the content components that can be used to build a learning experience, and provides the description for packaging content objects to ensure successful exchanges between administrative systems. In addition, using a standard set of metadata elements to describe content components within the learning experience for searching and identifying learning content is embodied in the CAM. The CAM also includes sequencing rules that can be applied to the organization of the learning content [25].

- The SCORM RTE defines three components to achieve interoperability between Sharable Content Objects (SCOs) and LMSs, which are known as RTE Management, Application Programming Interface (API) and RTE Data Model. RTE provides common content object launch and communication mechanisms for LMSs to launch content objects, communicate with content, and predefine data structures when exchanging content with other LMSs [26]. Based on these features, LOs that are created by any SCORM-compliant authoring tool can be easily shared between different SCORM-conformant LMSs. Figure 2.3 illustrates the Run-Time Environment of SCORM.

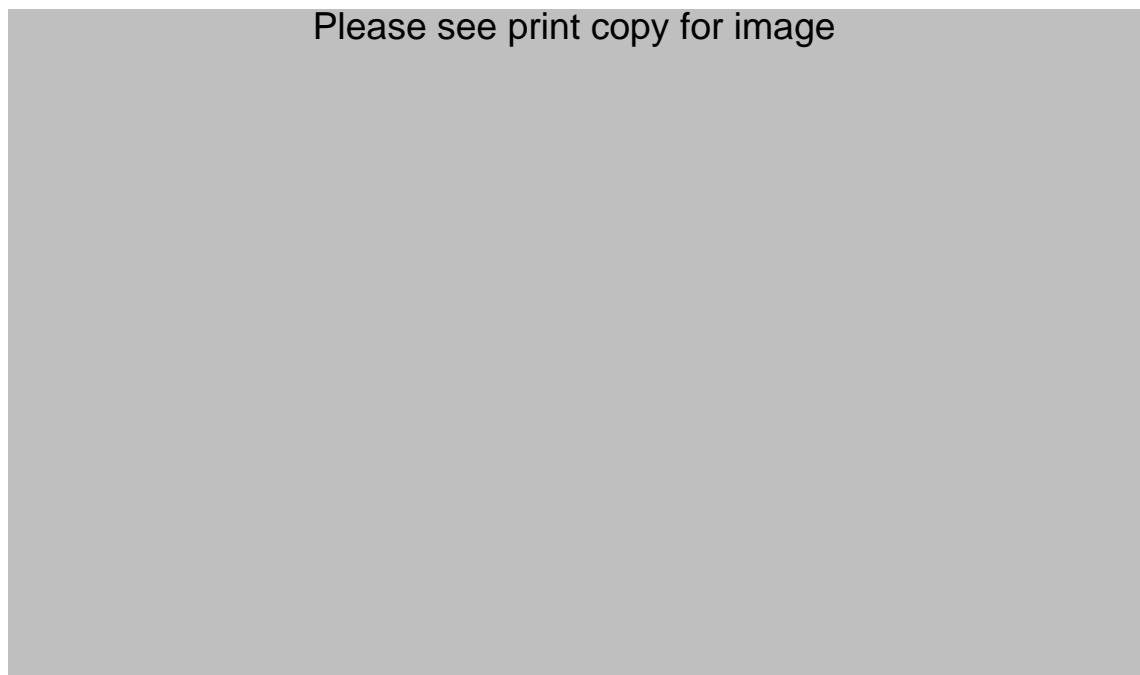


Figure 2.3: The Run-Time Environment of SCORM [26]

- The SCORM SN defines a set of rules that can be used to organize SCORM-conformant LOs and deliver these LOs the learners in the intended sequence and order of activities [27].

2.2.2 IMS Specifications

As a non-profit organization, the mission of the IMS Global Learning Consortium is to promote the adoption of learning technology and to develop the open technical specifications for interoperable learning technology [28]. IMS develops a series of open specifications for packaging, searching and location of e-Learning content, tracking and

reporting of learner progress, and evaluating learning outcomes. Two of these specifications have been adapted in the SCORM 2004 3rd Edition [19]:

- The IMS Content & Packing Specification, which defines how to encapsulate RLOs into interoperable, distributable packages that can be accessed and delivered by a variety of administration systems [20].
- The IMS Simple Sequencing Specification, which defines a method for describing the learning sequences in which RLOs are represented to the learner through a collection of learning activities [21].

Other IMS specifications that are wholly or partially involved with learning content development are as follows:

- The IMS Learning Resources Meta-data Specification, which defines a structure of metadata elements for describing learning resources such that they can be searched and located in the administration system [22]. This specification has been adopted in the SCORM version 1.2.
- The IMS Question & Test Interoperability (QTI) Specification, which defines a method for producing assessment information that allows questions, examinations and results to be shared across different administrative and assessment systems [23].

2.2.3 IEEE /LTSC Learning Object Metadata (LOM) Standard

IEEE/LTSC develops internationally accredited technical standards, and recommended practices and guidelines for e-Learning related technologies. The LOM standard specifies a conceptual metadata schema. The semantics, vocabulary and extensions of metadata are defined in this schema to facilitate the reusability and interoperability of LOs. Relevant characteristics of a LO can be described by metadata items that are specified in this standard. These metadata items can be sorted into nine categories: General, life cycle, meta-metadata, technical, educational, rights, relation, annotation and classification [12].

2.3 E-Learning Systems

An e-Learning system is an integrated software package that supports flexible and distributed learning through the Internet. E-Learning systems not only allow learners to access online course materials anytime and anywhere, but also enable instructors to manage learning resources and activities via the Internet. Currently, Learning Management System (LMS), Learning Content Management System (LCMS) and Learning Object Repository (LOR) are three types of e-Learning systems commonly used in educational institutions.

- *Learning Management System (LMS)*

A LMS is a web-based software application that offers multiple functions to support learning-related administrative tasks such as creating and publishing online courses, registering learners, providing access to online course and learning resources, tracking learners' progress and participation, and evaluating learners' obtained knowledge [18].

- *Learning Content Management System (LCMS)*

A LCMS is an e-Learning system that allows instructional designers to convert content formats, and create and manage LOs. Through a LCMS, LOs can be organized into learning sequences, and aggregated together into e-Learning courses. Most LCMSs also provide powerful authoring tools, templates and customized interfaces to help content authors to create high-quality learning content with minimal programming skill requirements [18].

- *Learning Object Repository (LOR)*

A LOR is a digital library used for the storage, search, review and retrieval of LOs. By using the LOR, LOs can be stored locally and accessed remotely through the Internet [29]. Recently, many instructional institutions recognized the important role of a LOR and built their own LORs; these online LORs not only improved the accessibility of LOs but also promoted the reusability of LOs [30].

2.4 Learning Content Development

Learning content development is a complex process that is constrained by many essential factors and involves a variety of personnel cooperating to achieve desired outcomes. Many authors and content developers have proposed advanced e-Learning

instructional methodologies that help to reduce the cost and the complexity of web-based content development. Normally, these methodologies refer to a term called Instructional System Design (ISD).

"ISD is the recommended process for designing, developing, and implementing learning programs" [18].

For content development, the process consists broadly of analysing the learners' needs, defining the educational objectives, and creating activities to assist learning and enhance learning experiences. There are numerous instructional design models, but many models are based on the ADDIE model [31]. The ADDIE model is the most commonly used model for creating learning content, and the model contains five phases: Analysis, design, development, implementation and evaluation (shown in Figure 2.4).



Figure 2.4: The ADDIE Model [31]

For developing learning content, the activities and outcomes associated with each phase of the ADDIE model may be summarized as follows [31]:

1. *Analysis*, during which instructional designers clarify the instructional goals and objects, determine the target learners, analyse existing resources, investigate the project implementation constraints, and estimate the project budget.

2. *Design*, during which instructional designers translate the project objectives into detailed design documents, select related technologies involved with content development, determine content structure and sequence, decide on content format and method of delivery, specify evaluation methodology and quantify the costs for content development, implementation and evaluation.
3. *Development*, during which the content developer creates the learning content by following the detailed design documents, checks the quality of the created learning content, stores and manages content for future use, and reviews the costs for content implementation and evaluation.
4. *Implementation*, during which the subject matter experts publish learning content and deliver content to the target learners, track learning processes and participation, and collect data and participant feedback for evaluation.
5. *Evaluation*, during which an instructional designer assesses the effectiveness of the learning content, reviews the project performance, and reports and records the results for improvement.

The ADDIE model is widely accepted in the e-Learning industry, and the process within the ADDIE model may be adjusted according to the project complexity. It is clear that different development strategies will be adopted based on different project budgets. To classify an e-Learning project, Saul Carliner suggested a three-tiered approach where an e-Learning project can be allocated into one of three tiers based on the effort and investment [18]. Each tier is described as follows:

- *Bronze*

The bronze projects are the most basic content development projects in e-Learning, thus the least effort in instructional design is needed. Normally, these projects have either a limited impact on the instructional sector or a limited number of learners. In the typical bronze project, rather than redesigning or recreating content, existing learning materials are maximally utilized and converted to learning content. Learning content may be compiled from lecture notes or presentations where the primary purpose is to reach a limited number of learners [18].

Due to limited budgets, bronze projects are often executed by the subject matter experts themselves. Authoring tools are usually used to convert the slides from an existing presentation or from a recording of a lecture. Easy-to-use e-Learning systems such as Moodle [32], Claroline [33] and Blackboard [34] are used for managing and publishing learning content [18].

Because of the relatively low costs of development, rapid production of bronze projects is one of the key reasons for the growth of learning resources in e-Learning systems. However, limited budgets and limited technical skills of subject matter experts constrain the quality of the created learning content. Therefore, the created learning content in bronze projects is not intended to be reused [18].

● *Silver*

Compared to bronze projects, silver projects have either a high impact on the instructional sector or a high number of learners. Silver projects require a significant investment of resources and thus may involve some instructional design effort. In a typical silver project, learning content is developed for technical training courses or an online format of an existing traditionally delivered course. Owing to most of these courses requiring interactive learning content with an attractive visual appearance, the roles of instructional designers have become especially important. Instructional designers must not only have strong ISD skills, but also strong content production skills [18].

However, silver projects are normally short on content materials. As a result, instructional designers need to spend more development time creating the required learning content, such as high quality graphics or animations. Existing e-Learning standards and educational models may be adopted to ensure consistency among content developers and to enhance the created content quality [18]. Due to the considerable effort required for instructional design, the quality of the created learning content in silver projects can be assured and present the potential to be reused in future.

● *Platinum*

As the top tier of e-Learning projects, platinum projects have both a high impact on the instructional sectors and a high number of learners. The production of platinum projects

require significant funds and investment in resources, hence these projects are undertaken by professional instructional institutions. Since sponsors expect investment returns, platinum courses often focus on high-impact topics and attract a wide variety of learners. These platinum courses are normally high-volume off-the-shelf e-Learning courses with high-quality interactive learning content and related learning activities [18].

Typically, a platinum project requires the strictest instructional design and is implemented by a variety of personnel resources. Personnel involved include instructional designers for planning and designing learning content, graphic artists for creating animations, video and other media elements, content authors for producing learning content, quality assurance technicians for evaluating content quality, and webmasters for publishing learning content and managing online courses [3]. Following the industry standards for the design and development of learning content, the created learning content in platinum projects is of high-value and assured quality; hence, such content can be retailed, shared and reused.

In summary, according to Carliner's three-tiered approach [18], more complex projects will require more time and incur higher costs in the analysis and design phases. Therefore, a successful design phase can reduce both time and cost in the following development and implementation processes. Table 2.1 indicates the estimated time for each step of the ADDIE process according to the level of complexity.

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Table 2.1: The Estimated Time for Each Step of the ADDIE Process by Level of Complexity [7]

2.5 Conclusion

In this chapter, a literature review on the concept of LOs and its underlying technologies has been presented. This review indicated that the LOs, as a new concept of reusing educational materials, have the potential to accelerate learning content development and reduce the development cost. E-Learning standards and systems introduced in this chapter also show the technical support available for implementing LOs in the design, development and publication of learning content. Focusing on developing learning content as RLOs and identifying variables that influence the cost of content development are addressed in the next chapter.

CHAPTER 3. IDENTIFICATION OF VARIABLES INFLUENCING THE COST OF LEARNING CONTENT DEVELOPMENT

As with any other type of project, learning content development has the limitations of staying within budget and on time. These limitations are affected by a number of factors which have a direct impact on content development; hence, a successful project will take all of these factors into account. However, to construct a cost-effective model from a technical point of view, variables that influence the cost of learning content development should be identified. Through taking control of these seemingly controllable variables, a cost-effective content development model can be constructed.

This chapter provides a discussion of the key factors that affect e-Learning content development. Through presenting and analysing the entire process of content development with these factors, variables that influence the cost of learning content development are identified. After identification of the variables, the significance of each variable in the context of cost is investigated and documented.

3.1 Essential Factors Affecting Learning Content Development

In contrast to traditional learning content development, factors to be considered in the development of learning content for e-Learning encompass pedagogy and technology related matters. In pedagogy, learning theories and educational models are covered. Moreover, other issues related to technology infrastructure including a wide range of hardware, software and connectivity options as well as standards, bandwidth and access technologies are then discussed.

According to a research report from the Policy and Practice in Design, Implementation and Publication of Digital Learning Content for Tertiary Education project, which is sponsored by the Iranian Telecommunication Research Center (ITRC), factors affecting content development highlighted include [10]:

- | | |
|----------------------------------------|-------------------------|
| 1. Pedagogy | 2. Educational Models |
| 3. Design, Development and Publication | 4. Interaction |
| 5. Bandwidth and Access Technology | 6. Standards |
| 7. Production Technologies | 8. E-Learning Platforms |
| 9. Required Resources | 10. Evaluation |

This chapter will explore how these listed factors affect learning content development.

3.1.1 Pedagogy

Pedagogy is a term that generally refers to strategies of instruction or a style of instruction; it is also referred to as the correct use of teaching strategies [35]. Pedagogy is normally included within the doctrine of an educational model. Any learning content development should consciously support the deployment of particular pedagogical approaches. Keegan classified these learning theories into three groupings [35]: Theories of autonomy and independence, theory of industrialization, and theories of interaction and communication.

According to the theories of autonomy and independence, learning must happen independently and the learner must be able to act autonomously in WBT. Moreover, as a new form of industrialized technology-based education, the theory of industrialization states that new technologies should be used to improve the development of learning content. In addition, the theories of interaction and communication emphasize correspondence education, thus the development of learning content should focus on the interaction between learner and content, and the immediate and individualised communication between participants [35].

3.1.2 Educational Model

Educational model is a term that usually refers to theoretical models that propose methods of learning or teaching. When learning content creation is based on an educational model, the process of development can be simplified. In addition, an educational model also defines the delivery method of learning content. In WBT, a distributed learning model has been widely used as the default model for developing and publishing learning content.

A distributed learning model is an instructional model that allows instructors, students, and content to be located in different, decentralized locations whereby instruction and learning take place independent of time and location (Figure 3.1). The distributed learning model can be used in combination with traditional classroom-based courses, with traditional distance learning courses, or it can be used to create wholly virtual classrooms [36].

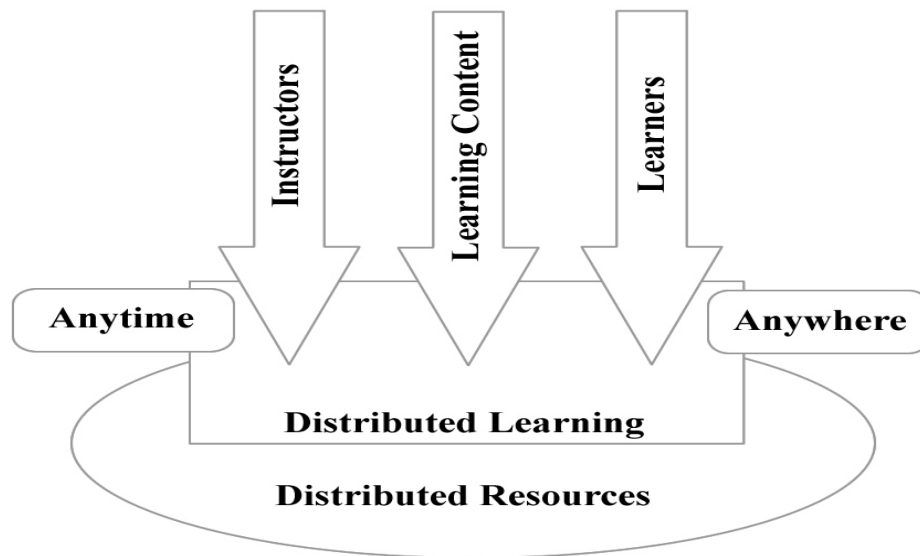


Figure 3.1: Distributed Learning Model

3.1.3 Design, Development and Publication

Design, development and publication are the three important phases of the learning content development process. The design of learning content may focus on target learners or educational purposes. The considerations normally taken into account in learning content design include determining the educational model and e-Learning standards, designing the structure of the learning content and its components, selecting appropriate production and publication technologies, and establishing the evaluation goal of the learning outcomes. The development phase simply executes the detailed design documents formed in the design phase. In the publication stage, created learning content will be published and delivered to target learners via the Internet.

The processes of design, development and publication of learning content involve a careful mixture of rest factors, as shown in Figure 1.1. The details regarding the process of learning content development incorporating these factors will be explained further in Section 3.2.

3.1.4 Interaction

To create learning content for WBT, instructional interactions should be considered because they are more likely to attract learner interest and provide mental stimulation. Interactive learning content not only engages the learner in meaningful learning activity, but also improves learning outcomes by enhancing the learning experience. Highly

interactive learning content allows learners to communicate with the content, and provide further information based on the learners' feedback [37]. This type of highly interactive learning content usually involves organized learning activities with combinations of text, graphics, audio, video, and animations. To evaluate interactive learning content, S. Codone provided descriptions of four interactivity levels in e-Learning, as outlined below [3]:

- *Interactivity Level 1 (Low Interactivity)*: Learning content at this level is normally used for introducing an idea or concept in a linear format which can be considered as a 'page turner'. As a result, learning content in level 1 is encapsulated in read-only file formats such as PDF or Microsoft PowerPoint; learners have little or no control over the learning sequences or time events within the content. Minimal interactivity is required from content composed of pure text, simple graphics, clip art and simple forward/backward navigation [3].
- *Interactivity Level 2 (Moderate Interactivity)*: Learning content at this level is normally used for demonstrating non-complex operations such as simple procedures and steps or complex knowledge presentations. Graphics and simple animations such as GIF or Flash with accompanying audio narration are widely used to present emulations or simulations. Content navigation often includes menus, forward/backward navigation, index map pages, and branching and glossaries, which offers more control over the content compared to level 1 [3].
- *Interactivity Level 3 (Intermediate Interaction)*: Learning content at this level is normally used for explaining more complex information such as the operation of a system or equipment, model procedures or complex images. Learners are allowed to take an increased level of control over the content. Learning content with multiple screens or windows often embed video, graphics or a combination of media files designed to provide tutorials to the user in this level [3].
- *Interactivity Level 4 (Advanced Interaction/Simulation)*: Learning content at this level is normally used for detailed presentations and highly complex information. Learners are allowed to take almost full control over the learning content. Extremely complex animations and videos with full interaction are adopted in the learning content for demonstrating complicated operations and maintenance

procedures, and all of the elements of levels 1-3 may also be adopted in this level [3].

3.1.5 Bandwidth and Access Technology

In e-Learning, bandwidth means the speed of the learner's connection to the Internet. The WBT online courses are normally supported by a LMS and in this case, bandwidth can be considered as the amount of data that travels between the learner's PC and the LMS in a specified time period [38].

Bandwidth is the primary factor that affects the development of learning content. The amount of available bandwidth determines whether or not learning content can contain audio, video and animations. For downloading or streaming large media files such as audio and video, a faster connection is needed [39].

In addition, learners are distributed geographically and may access the LMS through different Internet access technologies. Some learners may use a dial-up modem with low bandwidth to access the learning content, whilst others may access learning content using high bandwidth Internet connections with technology such as a Digital Subscriber Line (DSL), cable modems or satellite. Learning content that contains excessive audio and video files will cause long delays in downloading the files when the learner has a low bandwidth connection; hence, it is not practical to use audio or video extensively in learning content [40].

Furthermore, the connection bandwidth between the LMS server and backbone should be taken into account: It needs to provide a quality service for learners accessing learning content during peak hours [40].

3.1.6 Standards

Technical standards aim to simplify the development, search, exchange and access of learning content. Standards and specifications that influence the development of learning content can be categorized as follows:

- *Standards for Courseware:*

The standards for courseware fall into two basic categories [2]:

1. The interoperability standards define how content communicates with administrative systems such as LMS and LCMS to exchange data about learners and their progress. Exchangeable data normally include a learner's identification, the usage of learning content, and assessment results.
2. The content-packing standards define how created learning content should be packaged for launching into the administrative system, exchanged between systems, and stored in content repositories such that it can be easily searched, accessed, and reused.

- *Standards for Content Development Tools:*

There are a lot of commercial and open source content development tools, and these authoring tools are all standards conformant. Some of these applications provide functions that assist the content author to create SCORM-conformant learning content with a minimum understanding of standards and specifications [2].

- *Standards for Assessment Tools:*

The QTI specification from IMS describes a standard method of storing and exchanging test content and assessment results. This specification has been adopted or supported by a range of LMSs and LCMSs and it is expected that this specification will eventually be incorporated into the SCORM. Therefore, a QTI-conformant tool is suggested to content authors who are searching for a test generation or assessment tool [2].

- *Standards for Administrative Systems:*

The main purpose of these standards is to integrate learning content and administrative systems. Therefore, standards that apply to administrative systems (LMSs and LCMSs) are similar as those standards developed for courseware, interoperability standards and content-packaging standards. [2].

3.1.7 Production Technologies

Design, development and publication of learning content require a mixture of hardware components and software applications. For developing learning content, hardware

components normally include development workstations along with a network server to support the management and storage of created content and enable collaborative development. Additionally, software applications include, but are not limited to, an operating system, web browser, authoring tools, web editing tools, multimedia file editors, and text editors. Within these software applications, authoring tools that help content authors to create and package learning content should be highlighted. For the delivery of learning content, e-Learning platforms are widely used.

3.1.8 E-Learning Platforms

For publishing learning content, a complete e-Learning platform typically consists of an e-Learning hardware environment and an e-Learning software platform. The main elements of an e-Learning hardware platform are e-Learning servers, multimedia terminals, and Information and Communication Technology (ICT) infrastructure. An integrated e-Learning software platform contains web servers, databases, and LMS/LCMS/LOR systems. As a significant component of an e-Learning software platform, the web server supports the communication between target users with the LMS/LCMS/LOR systems via an Internet browser [41].

3.1.9 Required Resources

For any content development project, an investment into resources is required. These resources include financial, raw content, personnel, and physical resources. Furthermore, before establishing a content development project, existing resources that could facilitate the content development should be researched and analysed. It helps to assess the efforts which will continue to be utilized in future development. Through evaluating the existing resources, the project budget can be estimated and the feasibility of the project can be evaluated.

3.1.10 Evaluation

Evaluation is an important part of learning content development. The three main tasks of evaluation determine whether or not the learning content has met the instructional objectives, assesses the actual Return on Investment (ROI) of content development, evaluates learning outcomes, and collects valuable feedback such that the content can be continually improved [7].

The primary purpose of evaluation in content development is to improve the quality of the learning content. The steps of the evaluation process normally include defining the objectives of the evaluation, selecting the data collection methods, and determining the methodologies and technologies required for evaluation. Kirkpatrick defined a four-level evaluation model for assessing the impact of the learning experience [7]; Table 3.1 provides simple definitions for each level.

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Table 3.1: Definitions of the Four-level Evaluation Model [7]

3.2 The Process of Learning Content Development

A trend has been seen whereby Learning Objects (LOs) are implemented as flexible teaching and learning mechanisms that provide cost-effective interactive learning for WBT in the e-Learning industry. The reusability of LOs is the most attractive feature: By avoiding repeatedly spending time and energy on producing multiple versions of similar learning content, and sharing single versions of the same LOs at a much lower cost between different instructional institutions, the overall costs of learning content development can be reduced.

The target cost-effective model will concentrate on offering an effective way to develop standards conformant LOs with assured quality. As a result, the process of learning content development will focus on the production of LOs. As shown in Table 2.1, design, development and publication of learning content could affect up to 70% of the total development cost [7]. Based on the ADDIE model, the process of learning content development is narrowed and named as three processes (Figure 3.2): Planning and design, development, and publication and evaluation.

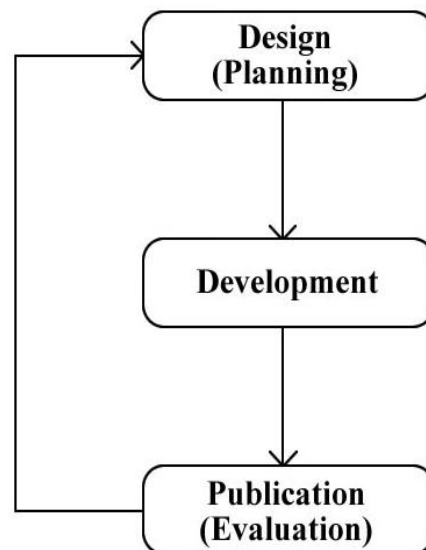


Figure 3.2: The Process of Learning Content Development

3.2.1 Planning and Design

In the first phase, the instructional designer concentrates on framing the development plan, including the analysis of instructional objectives and target learners, and the evaluation of pedagogical and economical effects of the plan. Subsequently, the

educational model is determined to provide an infrastructure for learning content development. Based on the adoption model, existing resources are researched and the project budget is also estimated. Based on these works, a project plan with a time schedule can be established to ensure that the implementations occur within a quality framework [42].

The design process is the most important part of learning content development, thus the instructional designer should consider suitable ways to deliver learning content to target learners by taking network bandwidth and access into account. Moreover, the designer decides on the standards that will be used in the development, and purchase the required production and publication hardware and software tools.

In accordance with the instructional objectives and aims, subject matter experts start to clarify the desired learning content with their experience. Following the selected standards, the structure of each LO and its components are determined, including the content hierarchy, modularity and interaction level [42]. The authorized learning resources such as books and papers may be excerpted to enhance the quality of the learning content. In addition, designing an evaluation method for measuring the quality of the LOs is also included in this phase. At the end of design phase, detailed design documents should be formed to assist subsequent processes.

3.2.2 Development

After the design phase, development plans are implemented and learning content is created. In the learning content development process, the project manager is in charge of production schedules and assigns workloads to personnel. The graphic artist produces the media files to match requirements for the interactive learning content. By using authoring tools, the authoring specialist produces LOs in batches. After the LOs are created, the quality assurance technician carefully evaluates the quality of the LOs. The LOs which have passed the quality control are saved in a central object repository and managed by the database specialist. Before publishing the learning content, the subject matter expert searches and retrieves related LOs from the repository, organizes them into learning sequences, and packages them into large units such as lessons or a course through the LCMS.

3.2.3 Publication and Evaluation

During the publication process, the prepared course is posted on LMS and delivered to target learners through the Internet. LMS provides a user-friendly learning environment to help learners to access the desired learning content. Along with the publication of learning content, the webmaster creates related learning activities on LMS to enhance learning experiences and outcomes.

The evaluation process will be implemented as soon as the content is published. Evaluation should focus on the overall quality of the learning activities and learning outcomes. To determine whether a LO satisfies the desired instructional objective, the instructional designer is required to tie the assessment of the learners' progress and outcomes with specific LOs. Therefore, learners' assessment results should be collected to evaluate the quality of the LOs, and the evaluation can help the instructional designer to further improve the LOs [43].

3.3 Identification of Variables Influencing the Cost of Learning Content Development

Through analysing the descriptions of the design, development and publication processes, variables that influence the development cost can be easily identified (see Figure 3.3).

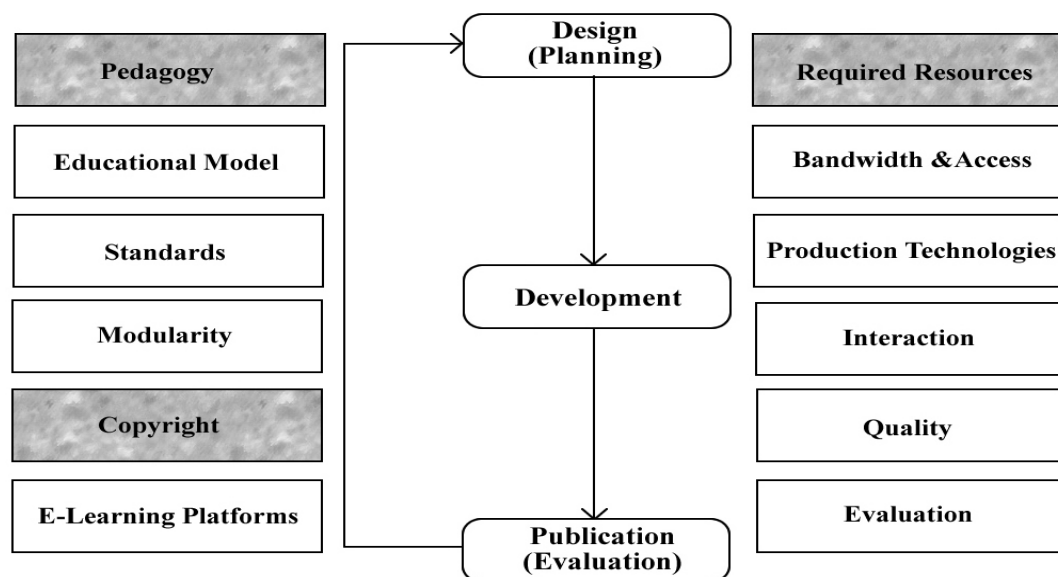


Figure 3.3: Identification of Variables Influencing the Cost of Learning Content Development

These variables are:

- | | |
|--------------------------|----------------------------|
| 1. Required Resources | 2. Pedagogy |
| 3. Educational Model | 4. Bandwidth and Access |
| 5. Standards | 6. Production Technologies |
| 7. Modularity | 8. Interaction |
| 9. Copyright | 10. Quality |
| 11. E-Learning Platforms | 12. Evaluation |

The development cost may be directly or indirectly affected by these 12 variables.

These identified variables characterize and differentiate the diverse e-Learning technologies that are involved with content development. Because the target model seeks a technical method to reduce the cost of learning content development, a potential solution for constructing the target model is to take control of these controllable variables. Since the extent and significance of each variable in the context of cost could differ, the impact of identified variables on the cost of learning content development should be investigated. The investigation can present a good understanding of the identified variables and provide initial ideas for controlling these variables.

However, the impacts of pedagogy and required resources on the content development cost are not taken into account during the investigation. As discussed in Section 3.1, e-Learning development projects normally select a mature educational model that integrates the pedagogical framework and educational technology for content development; hence, most content development projects do not allocate costs to design new learning theories and models. Moreover, due to existing resources that vary in different content development projects, the investment in required resources is hard to estimate. The impact of the remaining 10 identified variables on different aspects of the development cost is now described and documented.

3.3.1 Education Model

Normally, the education model specifies the content delivery method where the cost of learning content development could be affected differently according to the selected model. However, developing learning content for e-Learning and adopting a distributed learning model can decrease the cost of content development.

In fact, there are two types of costs in e-Learning: Content development and maintenance costs, and incremental costs per learner. The development costs are concentrated in the design, development and publication phases. The incremental costs are incurred after content publication by learner support, tutorials, equipment operation, maintenance and related services [44].

Initially, the costs of distributed learning can be higher than typical lecture courses; however, these costs may be distributed among a larger group of learners because learning can occur anytime and anywhere via the Internet. Therefore, the economical benefit of distributed learning is that it distributes development costs over a larger numbers of learners and hence increases the efficiency of development costs and ROI [45].

3.3.2 Bandwidth and Access Technology

As the primary factor affecting learning content development, bandwidth and access technology influence the development cost in two ways: Firstly, the costs spent on the high bandwidth required for publishing learning content and supporting quality learning service; secondly, the efforts spent on constraining the size of each LO and its components due to the available bandwidth.

In fact, bandwidth in a network is always changing: It depends on the total available bandwidth and the number of current active users. In e-Learning, all online courses have a minimum bandwidth requirement, which can be calculated based on the data transfer rate and the size of each page in the learning content. It is very clear that a course that contains full motion video and audio will require much more bandwidth than a course composed of mostly text and images. However, if the target learners use access technology of lower bandwidth to browse learning content, the longer time taken to load the content will result in the course being deemed "broken" by the learners [39]. Once learners are blocked by an online course, they may never login to this course again.

Reducing the file sizes of learning content can be an effective way to solve this problem. It can be achieved by reducing utilization of audio and video in the learning content and using bandwidth-friendly file formats. As a rule of thumb, the file size of a web page within learning content should be less than 500KB for low bandwidth and less than

1MB for high bandwidth connections [46]. Moreover, compression tools can be used to compress multimedia files to satisfy the different bandwidth requirements [3]. Thus, it is prudent to consider the typical page components in a LO and Table 3.2 lists these page components and their typical sizes in kilobytes.

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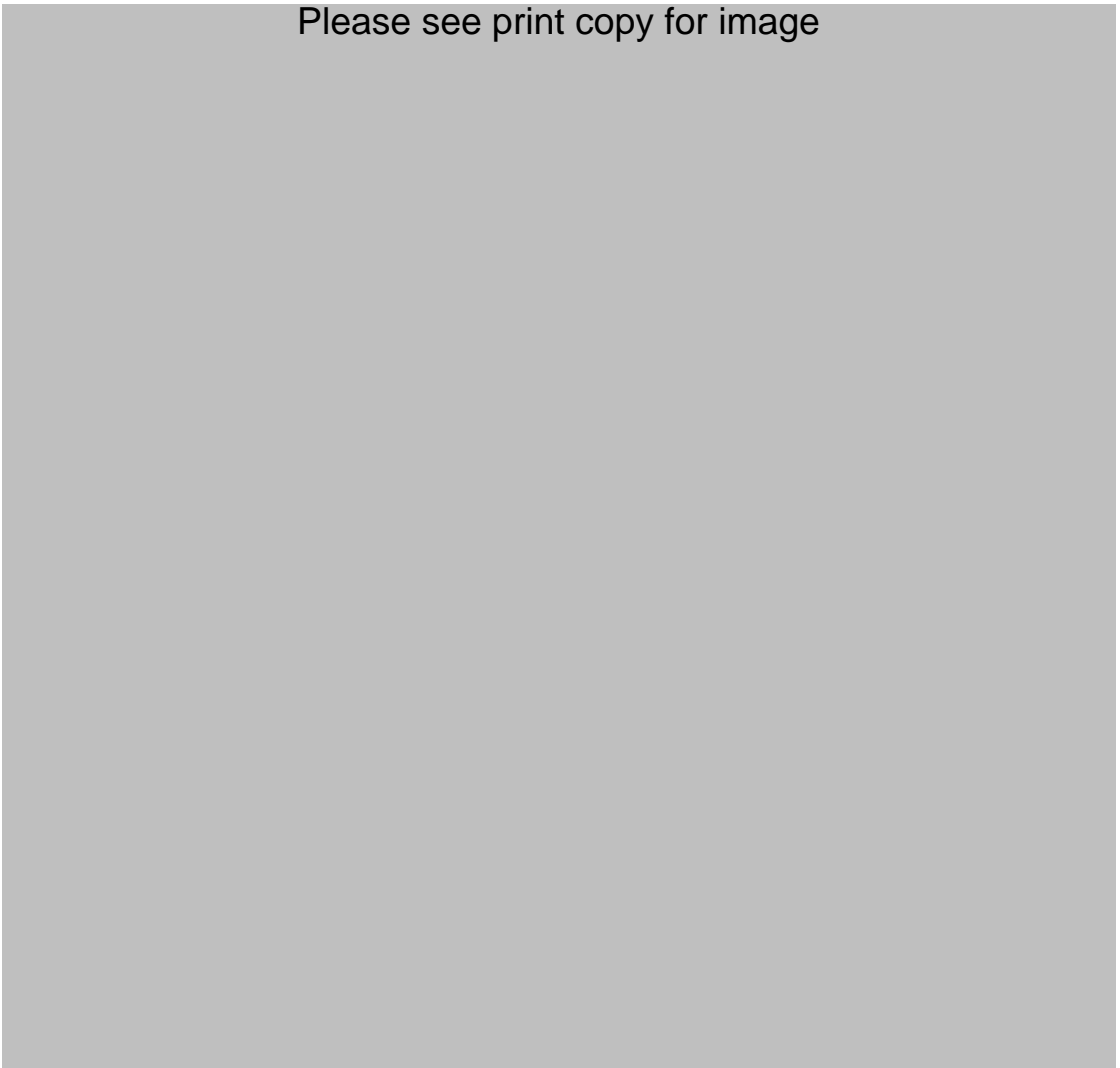


Table 3.2: Typical Page Components in a LO [3]

Another way to improve the learning experience is to suggest that the learner access learning content through broadband Internet. According to the Australian flexible learning framework, the minimum bandwidth requirement is 1Mbps downstream for 10 learners accessing content with embedded audio and video, but ideally four times this amount can provide a better and more satisfying learning experience [47]. No doubt,

improving the bandwidth between the LMS server and the backbone is also an effective way to enhance the quality of the learning service.

3.3.3 Standards

LO standards do not directly influence the cost of learning content development. However, following the standards when developing and publishing learning content could help to reduce both development time and costs. Standards conformant learning content can be ideally exchanged between different e-Learning software platforms. Moreover, some standards are developed to support administrative system tracking and reporting of learners' progress such that the costs of evaluation can be further reduced [2].

LO standards can be considered as an important component of e-Learning infrastructure. The selected standards in content development will affect the 'big picture' of purchasing learning content production and publication software. If institutions do not adopt uniform standards for content development, it may lead to unsuccessful investment on separate e-Learning software platforms. Extra efforts will be needed to share content between these platforms, thereby influencing the total cost of learning content development.

3.3.4 Production Technologies

To produce learning content, instructional designers must choose the technologies that they will use to develop their product; these technologies include computer hardware and software.

For the production of learning content, a common personal computer could meet the requirements. In addition to computer hardware, more than half of the development cost is spent on purchasing production and publication software. Choosing different software will affect the development cost: For example, the price range of SCORM-conformant authoring tools varies from \$200 to \$2000 per copy. Therefore, selecting appropriate production and publication software becomes a key in reducing the development cost.

In fact, there are some Open Source Software (OSS) packages that help content authors to produce LOs with similar functionality compared to commercial packages. Adopting OSS packages can reduce the cost of learning content development to a minimum level and should be considered in the target model.

3.3.5 Modularity

In contrast to traditional learning content, LOs represent a new approach to the creation, delivery and manipulation of online learning material. The key idea behind LOs is that these digital chunks can be reused. To develop a RLO, the modularity of the LO can be a factor that influences the development cost. To investigate the modularity of a LO, the granularity and metadata tagged should be considered.

The reusability is often the most attractive feature of LOs. The value of the learning content is increased every time it is reused, and the development cost is also saved by avoiding new design and development time and efforts. Moreover, the possibility of selling RLOs or sharing them with partners shows a new business opportunity for the e-Learning market. To enhance the reusability of a LO, the granularity - the size of a given 'chunk' of learning materials - should be considered during development. If the 'chunk' is too large, it is very hard to reuse in the future. Conversely, if the 'chunk' is too small, it will increase the time and cost of development. Table 3.3 shows the cost of development based on different LO granularity.

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Table 3.3: The Cost of Development Based on Different LO Granularity [48]

Moreover, a LO with appropriately tagged metadata can reduce the time spent on researching and retrieving content in the LOR, thus facilitating rapid creation of online courses. These self-described LOs can also communicate with the LMS and LCMS to

enable tracking and reporting of a learner's progress, thus quality metadata is needed to enhance the reusability of a LO. Table 3.4 describes the relationships between metadata tagged on a LO and the cost of content development.

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Table 3.4: The Development Cost of LOs with or without Metadata Tagged [48]

3.3.6 Interaction

Interaction is a major feature of e-Learning. Most instructional institutions desire highly interactive e-Learning courses to both engage learners and motivate learner involvement. Highly interactive learning can cause more reaction and learner interaction, and eventually facilitate learning outcomes and increase knowledge retention [3]. Developing learning content at different interactivity levels will lead to different development costs. The learning content at higher interactivity levels will require more time and money to produce. Thus, the instructional designer should determine the interactivity level before the learning content is developed as it will directly affect the cost of learning content development.

Furthermore, interaction between instructors and learners, and learners themselves, is also important in e-Learning. The communication between the instructor and learners not only helps learners to solve their problems during learning, but also provides feedback from learners where the instructor can ensure comprehension of learning content and obtain information on the learners' performance. Moreover, by sharing their own learning experiences with other learners within the forums, positive learning outcomes can be achieved. Therefore, costs and efforts should focus on setting up a communication platform for instructors and learners.

3.3.7 Copyright

The impact of copyright on the cost of learning content development comes from two sides. Firstly, as learning materials originate from different resources, it must be ensured that the copyright of these materials is acknowledged appropriately before the LO is produced. If the designer is unlawful in using these learning resources, it may cause legal problems. Therefore, when using copyright learning materials, purchasing licenses or obtaining the copyright permission from authors is required. Secondly, the copyright of the created learning content should be protected. To protect the developed learning content, digital copyright and licensing mechanisms are needed. By employing these mechanisms, the learner will request and be granted a license when they are accessing a web page that contains learning content. Moreover, the authentication systems within the LMS/LCMS/LOR can ensure that only authorized users can access the relevant learning content. In this way, the copyright of the produced learning content can be assured.

3.3.8 Quality

The goal of learning content development is to produce RLOs with assured quality. Therefore, the costs and time spent on quality assurance and improvement during the development process are necessary. The composite aspects of quality control and inspection in e-Learning include quality checking for learning resources, created LOs, learning processes and practices, and learning outcomes.

Learning resources with assured quality can accelerate learning and promote the quality of target LOs. The quality inspection of created LOs should focus on both technical and pedagogical qualities. During the technical quality inspection, independent verification of the quality of a particular LO is required, where the quality detection includes the accessibility of the LO and the quality of the metadata tagged. In addition, the content of each LO should match the specific pedagogical approach and instructional objectives.

Furthermore, the quality of learning processes and practices should be checked before release to the target learners. Learners can feel discouraged in a low quality learning environment, which impairs learning outcomes. Similar to the quality inspection of LOs, the quality of the entire course should be assured before delivery to the participants.

Table 3.5 contains descriptions of three typical quality levels that can be used as guidelines in inspecting created LOs and learning activities.

Quality Level	Description
Low Level	<ol style="list-style-type: none"> 1. No adoption of authorized learning resources. 2. Raw learning content (low interactivity) with accessibility problems. 3. Does not comply with e-Learning standards (no metadata tagged). 4. Does not have relevant learning activities and practices. 5. Learning outcomes basically match learning objectives.
Medium Level	<ol style="list-style-type: none"> 1. Adopted authorized learning resources. 2. Well-structured and metadata-tagged learning content (moderate interactivity) with rare accessibility problems. 3. Compliant with popular e-Learning standards (SCORM, IMS). 4. Relevant learning activities and practices focusing on main learning objectives are offered. 5. Learning outcomes match learning objectives.
High Level	<ol style="list-style-type: none"> 1. Widely adopted authorized learning resources. 2. Elaborate, reviewed learning content (intermediate or advanced interactivity) with high quality metadata tagged. 3. Strict compliance with specific e-Learning standards. 4. Relevant learning activities and practices for each individual learning objective are offered. 5. Better learning experience and high quality learning outcomes.

Table 3.5: Three Quality Levels and Description

3.3.9 E-Learning Platforms

In practice, development costs and time are needed to set up a complete e-Learning platform. Typical e-Learning platforms for publishing learning content include e-Learning hardware and software platforms. These e-Learning software platforms include, but not limited to: LMS for publishing online courses, managing learning process and activities, and assessing learning outcomes; LCMS for organizing learning

sequences, combining LOs and forming online courses; and LOR for storing, searching and retrieving LOs.

The selection of e-Learning hardware platforms should be based on the number of target learners that the system needs to support. The price range of a network server can vary from several hundreds to thousands of dollars. Therefore, choosing different e-Learning software platforms will affect the development cost differently. For example, SCORM-conformant LMS and LCMS may charge according to the number of users. The technical support will also charge from hundreds to thousands of dollars per year. Choosing the most appropriate LMS/LCMS/LOR can improve the efficiency of the learning content development and enhance learners' learning experience. This will result in a considerable saving of development cost.

3.3.10 Evaluation

The total costs associated with learning content evaluation can be computed as the sum of two components: Costs associated with learning outcome assessment and learning process tracking. The evaluation objective and level should be determined before assessing learning outcomes. Different goals and levels of evaluation require different evaluation methods and technologies, thereby incurring different costs.

Furthermore, to support the evaluation, statistics of the entire learning process are required. Data collection methods are needed to track and collect data on each learner's learning process. In fact, a typical LMS offers functions that track the learning process. These functions can help the instructor to ensure that the learner has spent enough time on the learning content and followed the learning sequences. However, the LMS still requires instructors to monitor the system and collect data for evaluating the learning state of each individual learner, and provide suitable coaching if required. The cost of these processes should also be taken into account.

3.4 Conclusion

In brief, 12 variables influencing the cost of learning content development are identified in this chapter. The significances of the impacts from the 10 variables on the development cost are investigated. The investigation presents a good understanding of these identified variables and indicates potential solutions for controlling these variables. Furthermore, the investigation also shows that some identified variables contain parameters that are unpredictable and uncontrollable; hence, these parameters or variables should be excluded when constructing the cost-effective model. These 3 variables and 8 parameters are listed in Table 1.1, where the 3 variables include pedagogy, required resources, and copyright. In the next chapter, the relationships between that identified variables and each process of learning content development are discussed, and identified variables are prioritized based on their extent and impact on the development process.

CHAPTER 4. PRIORITIZATION OF VARIABLES INFLUENCING THE COST OF LEARNING CONTENT DEVELOPMENT

In Chapter 3, variables that influence the cost of learning content development have been identified and the impacts of each variable in the context of cost were discussed. The most suitable way to construct a target cost-effective model is to control these identified variables. Before establishing this model, it is necessary to investigate the distribution of the identified variables in the processes of learning content development. The investigation can help to estimate the extent of each variable's effect on the development cost and thus prioritize the variables in the model.

In this chapter, the relationships between identified variables in each process of content development are discussed. The prioritization of variables is conducted and utilised in sorting the identified variables associated with the learning content development process. Moreover, as mentioned in Section 3.3, variables and parameters that either have less impact on the cost or are not easy to minimise costs for are excluded in the target model. Therefore, the discussion of the variables distribution in the content development process does not take the variables 'pedagogy' and 'required resources' into account. However, variable the 'copyright' is still included and is put in place to support the integrity of the content development flowcharts.

4.1 Processes in Learning Content Development

Planning and design, development, and publication and evaluation are the three major processes in content development; the descriptions of these processes have been provided in Section 3.2. Each identified variable is involved in one or several processes, hence studying the distribution of the identified variables in different development processes could help to prioritize these variables. In addition, developing learning content as high quality Reusable Learning Objects (RLOs) can obtain added value every time these RLOs are reused. The target cost-effective model should not only consider the cost minimization, but also guarantee the quality of the created Learning Objects (LOs).

Normally, based on the different investments and budgets of a content development project, different development strategies will be adopted to ensure the implementation

of the project, thus the quality of the created LOs will be affected by these strategies. In this chapter, two extreme content development structures are investigated. The high cost structure represents the development strategies that are adopted in high budget content development projects, and the low cost structure consists of the development strategies that are used in the content development projects with budgetary limitations. It is assumed that LOs with assured quality can be created by following the high cost structure, and that the minimum development cost is spent when following the low cost structure. The detailed and careful deliberation of these two structures will result in the target cost-effective model.

The following sections will discuss the relationships between identified variables and the three main content development processes. After introducing the flowchart of each process, the high and low cost structures related to this process are described.

4.2 Learning Content Planning and Design Process

During the planning and design process, instructional objectives are prepared and documented. Focusing on these learning objectives, the project plan and detailed design documents are thus established. Instructional designers and subject matter experts play important roles and contribute their experiences in this phase. All of the identified variables are involved in this process. The development strategies of these variables are determined in the design process, which then impacts the following development processes. Figure 4.1 indicates the flowchart of the learning content planning and design process with the identified variables.

To establish an entire content development project plan, instructional designers start with the selection of the educational model where the delivery method of learning content is firstly determined. Then, standards that will be used for developing the LO are decided upon, and these standards include standards for content structure, packaging learning content, the metadata schemes, administrative systems, and assessment. Based on the selected standards, production and publication technologies are confirmed. This step may require the purchase of computer hardware, software, and e-Learning platforms, which are used for producing or publishing the learning content.

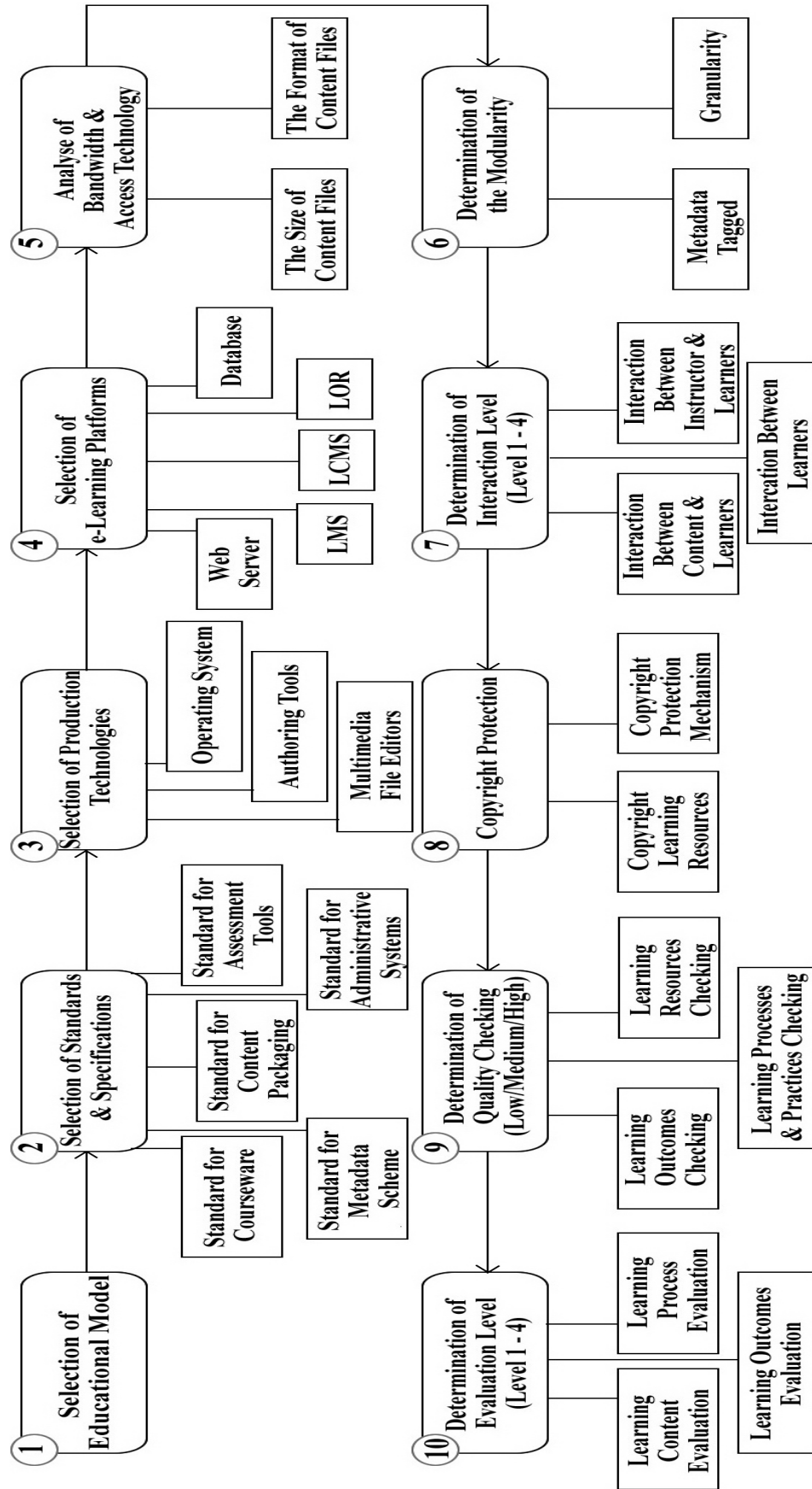


Figure 4.1: Learning Content Planning and Design Process

After deciding upon the relevant standards, subject matter experts start to design the objective, structure, and sequence of the LOs. Because LOs are delivered via the Internet, the bandwidth and access technologies constrain the size of each LO and its components. Therefore, the modularity of the LO and achieving the desired interactivity level should be clarified by the subject matter experts. Based on their experiences, authorized learning resources may be adopted in the content to facilitate positive learning outcomes.

Subsequently, according to the different quality requirements of the target LOs, different quality control and inspection mechanisms are selected. At the end of the design phase, instructional designers determine the evaluation level and choose the appropriate evaluation methods. All development strategies of the identified variables are recorded and documented in the detailed design documents. Based on the detailed design documents, the project manager completes the project plan, which includes the schedule for the development time, assigns the work to different personnel, and estimates the probable budget for the following processes.

4.2.1 Learning Content Planning and Design: Low Cost Structure

Projects with poor funding and hence budgetary constraints may follow a low cost structure; these projects can be considered as ‘bronze’ projects and are often initiated by the subject matter experts themselves. Because of the limited budget for learning content development, subject matter experts have to play different roles during the whole content development process. Normally, online courses created by following the low cost structure can be considered as an extension of existing traditional courses. Learning content for these courses is converted from existing learning resources, subject notes or traditional learning content. Therefore, minimal design efforts are required and content development mainly focuses on converting these learning materials into LOs. The development strategies adopted in the design process of these projects aim to minimise that development cost and facilitate easy implementation (see Figure 4.2).

The content design in the low cost structure is based on a distributed learning model. As the most popular learning content component model, SCORM is selected for aggregating and packaging LOs. For the purposes of reducing the total cost of content development, Open Source Software (OSS) packages are widely adopted for producing

and publishing learning content. In particular, an easy-to-use open source LMS is the undoubted choice for delivering learning content and managing learning activities [49].

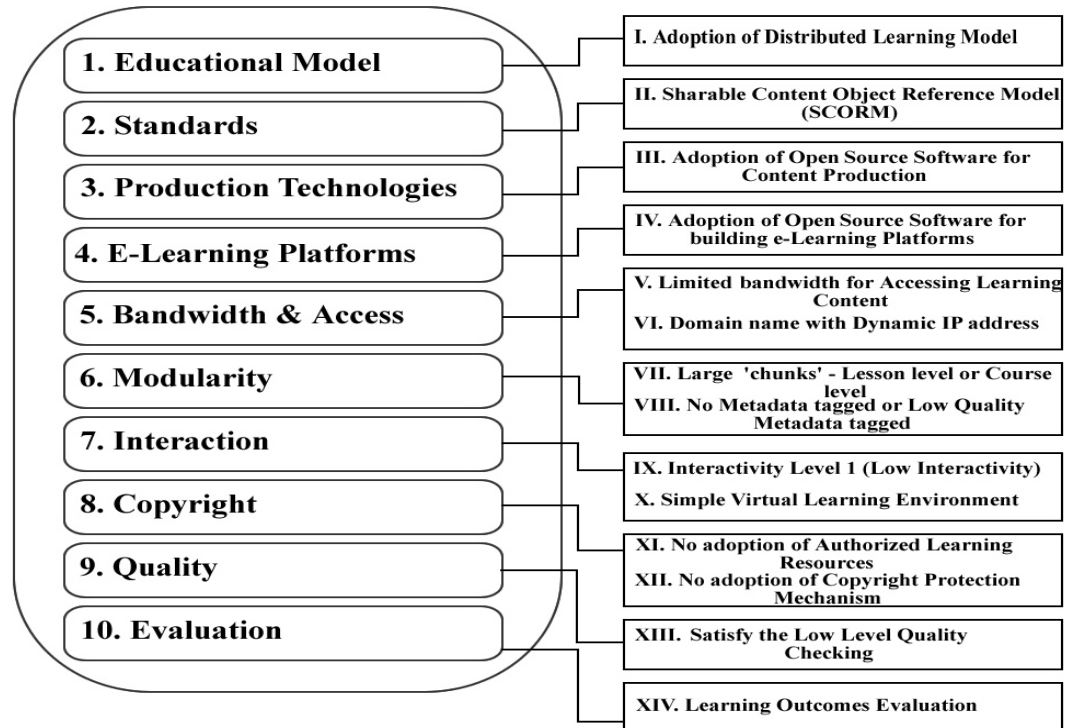


Figure 4.2: Learning Content Planning and Design - Low Cost Structure

Furthermore, poor funding has limited the investment in computer hardware and bandwidth for accessing online courses. Web servers are setup on common personal computers and connect to the Internet through common access technologies with a dynamic IP address. To reduce the development time, the granularity of each LO is designed as a large 'chunk' of learning materials such as a lesson or a course, and no metadata or low quality metadata is designed for target LOs.

Because e-Learning courses in the low cost structure are online versions of traditionally delivered courses, subject matter experts will not spend too much time and effort on designing highly interactive LOs and virtual learning environments. Most LOs in these online courses are 'page-turners', where the learner simply reads through pages of plain text. In addition, because there are enough learning resources for creating the learning content, there is no extra cost spent on authorized learning materials.

Moreover, the quality of the created LO in the low cost structure cannot be assured, but it should at least pass the low level quality checking and be successfully viewed in common Internet browsers. Normally, there is no assessment for the created LOs and online quizzes may be designed to evaluate the learners' learning outcomes. In brief, the lack of ISD in the low cost structure results in lower reusability of the designed LOs.

4.2.2 Learning Content Planning and Design: High Cost Structure

Well-funded projects with no budgetary limitations can be considered as 'Platinum' projects; these projects are normally undertaken by professional learning content providers. Pure or blended e-Learning courses are offered by these content providers, and development strategies in high cost structures are generally used to produce high quality LOs with high learner interaction (see Figure 4.3). Highly interactive learning content is an attractive factor for potential consumers; hence, different experts are employed by content providers to design and develop high quality LOs. In fact, the learning content design process is very important in a high cost structure: Organized detailed design documents and scheduled project plans can enable rapid creation of high quality RLOs.

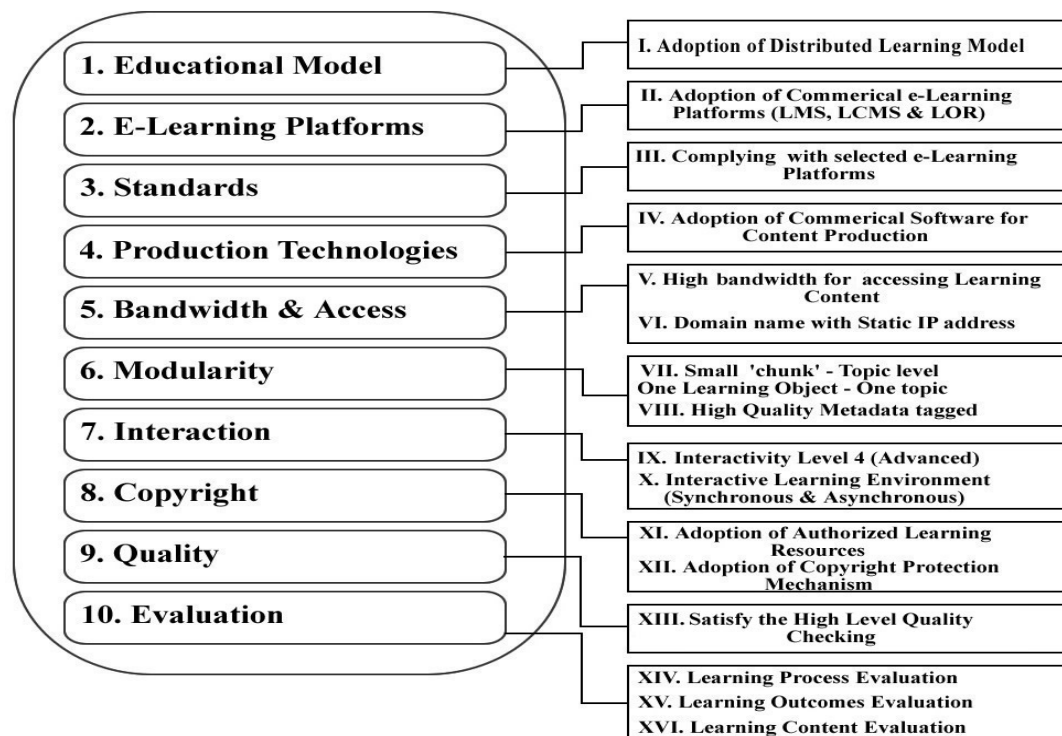


Figure 4.3: Learning Content Planning and Design - High Cost Structure

Similar to other content development projects, learning content design in a high cost structure is based on a distributed learning model. Commercial e-Learning software platforms are adopted to provide a virtual learning environment with reliable services in the high cost structure. These e-Learning software platforms could be purchased or developed by content providers themselves. Therefore, learning content is normally created for the specific LMS and complies with the standards supported in that LMS. In addition, due to ease of use and good technical support, commercial software packages are also the first choice for editing multimedia files and authoring LOs.

To provide better learning experiences and quality services, high bandwidth between web servers and the Internet is required. A leased line is the general choice for learning content publication in a high cost structure, where a static IP address with a unique, memorable domain name can enable a learner to quickly access the required learning content. To enhance the reusability of created LOs, each LO is designated a small 'chunk' of learning material that focuses on one learning objective. High quality metadata is also designed for each LO to enable future search and retrieval.

To facilitate positive learning outcomes, designing an interactive learning environment is also important. This environment should support interaction between different learners and their instructors. Moreover, interaction between learning content and learners should be taken into account. For a pure e-Learning course, the designed LOs are satisfied with the advanced interactivity level, and authorized learning resources are used for improving the quality of the LOs. On the other hand, due to a large investment in the creation of these LOs, copyright protection mechanisms are needed. Normally, the registration and authentication system within the LMS are widely used to ensure that learning resources only grant access to allowed learners.

In the high cost structure, created LOs can be sold to consumers for training or learning purposes; hence, the quality control and inspection mechanisms are designed and strictly implemented during the whole learning content development process. The quality of the LOs and learning activities should be checked before delivery or release to the target learners. Quality inspection essentially includes the checking of learning resources, learning processes and practices, and learning objectives.

Evaluation will be implemented as soon as content is published. The evaluation method and level should be previously designed and determined. Successful or unsuccessful content design processes will reflect on the assessment results. To obtain the necessary evaluation data, online quizzes, surveys, and assignments are designed as the direct assessment methods, whilst data collection from and analysis on the learner' level of participation are designed as the assistant evaluation methods. In summary, as enough time and effort are spent on the content design process, designed LOs have well-structured and assured quality that enable the LOs to be reused in future.

4.3 Learning Content Development Process

After the design phase, project plans should be executed, where learning content will be developed and delivered to the target learners. To produce learning content, the development process will follow the detailed design documents that were established in the design phase. Figure 4.4 illustrates the flowchart of a LO development process using the identified variables. Because each LO is a small, self-contained chunk of learning material that has one learning objective, developing learning content as LOs for a whole course requires repeating some steps of the process in Figure 4.4.

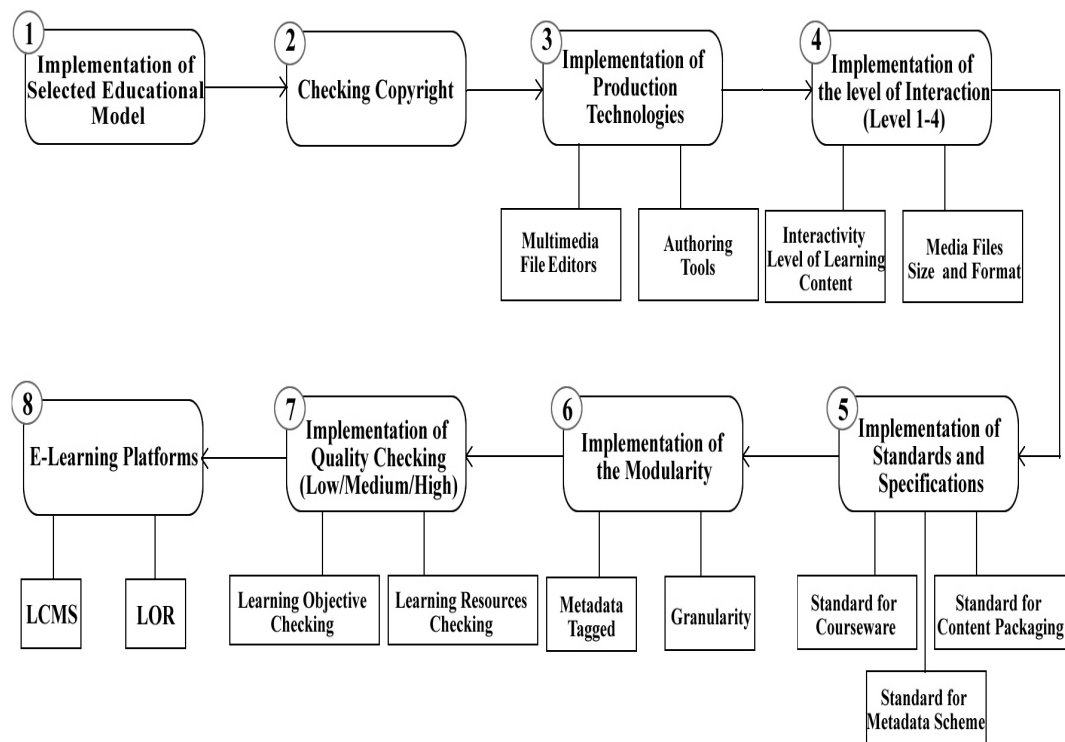


Figure 4.4: Learning Content Development Process

According to Figure 4.4, the creation of LOs is still based on the selected educational model. The adopted educational model has determined the learning content delivery method and provided infrastructure for learning content development. To produce the learning content, useful raw learning materials are collected and classified. Before using these learning materials, copyright checking is required. As these learning materials come from different resources, copyright checking can ensure the copyright of these materials is appropriately acknowledged to avoid legal problems.

After copyright checking, the raw learning materials are sorted and saved into different directories based on different learning objectives. Programmers and graphic artists start to process these learning materials. Usable tools such as text editors, web editors and media editors are used to accelerate the process. Based on the interactivity level, graphic artists add or delete media files accordingly; in particular, multimedia files are converted into appropriate sizes and formats. Authoring tools are then used to produce the LOs.

Based on the detailed design documents, a content author chooses the standards for developing courseware, content packaging and the metadata scheme. Subsequently, the prepared learning materials are imported into the authoring tool. The LO structure is built and relative resources are linked, and metadata is tagged to describe the characteristics of the LO. When all steps are finished, the content author previews the produced LO to ensure that all files are displayed correctly. The LO is then exported from the authoring tool and encapsulated into a zip file.

After the LO is exported, a quality assurance technician inspects the quality of the created LO. Quality checking includes inspection of the file size and learning performance. If the created LO matches the requirement, it will be saved into a LOR. Through the LOR, the database specialist can easily search, retrieve and manage these created LOs.

To prepare learning content for an e-Learning course, LOs that support learning objectives in the course are located and retrieved from the LOR. Subject matter experts import the retrieved LOs into a LCMS. Through LCMS, subject matter experts modify and organize these LOs into learning sequences. Sequential LOs are combined,

packaged and exported as content aggregation packages, and then an e-Learning course is integrated with these content packages to be created and published to the learners in the publication process.

The identified variables involved in this phase are the educational model, copyright, production technologies, interaction, standards, modularity, quality and e-Learning platforms. It is obvious that choosing different development strategies for these variables can directly influence the development cost. In contrast, different project budgets can also constrain the development strategies of these variables.

4.3.1 Learning Content Development: Low Cost Structure

The learning content produced in this structure are not recognised as pure LOs: Because of low budget, the learning content can be considered as encapsulating traditional digital learning content in a basic LO form. Figure 4.5 illustrates the low cost structure in the learning content development process.

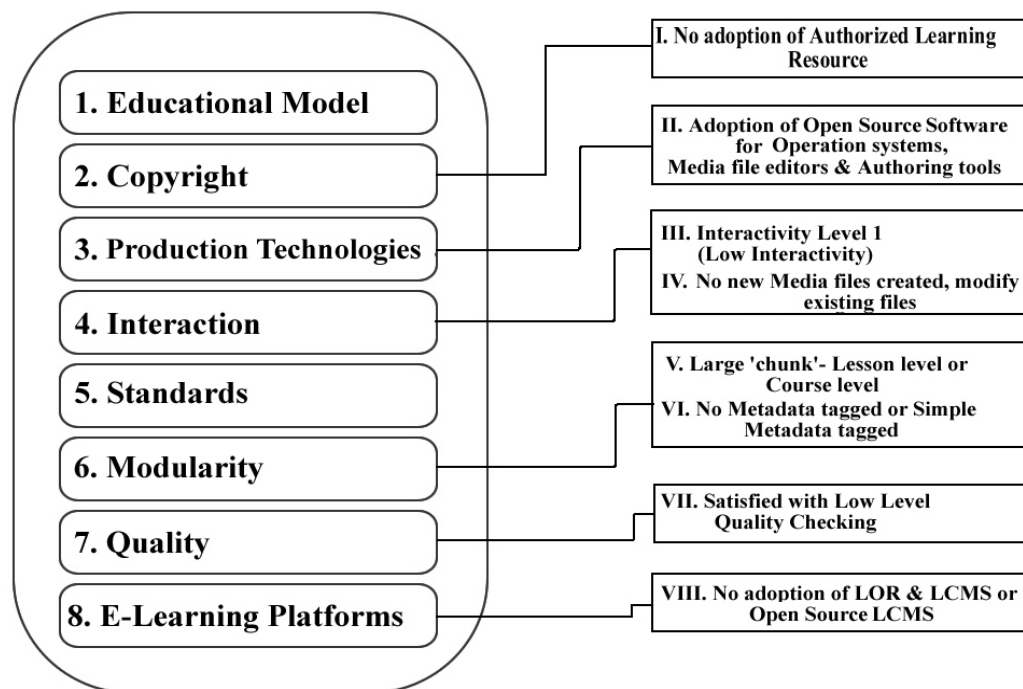


Figure 4.5: Learning Content Development - Low Cost Structure

In this development structure, no authorized learning resource is adopted in the creation of the LOs. This strategy can cut the cost of purchasing licenses and save time as

copyright permission is not required. Moreover, this structure also benefits from the adoption of open source or freeware applications, where these OSS packages can be used for editing media files, and authoring LOs.

In low cost structure, subject matter experts may play different roles during the production. The interactivity level of a LO heavily depends on the ability of the subject matter expert. In addition, LOs in this structure are normally constructed by modifying existing learning materials, and present page-turner, lantern slides and subject notes in PDF format. Hence, creating new media files to match the higher interactivity level is unrealistic and unnecessary.

Because the granularity of a LO in a low cost structure is designed as a large ‘chunk’ of learning material such as a lesson or a course, this results in a decreased number of created LOs and thus provides savings in the development cost. To further reduce the development cost, no metadata or simple metadata is tagged on these LOs. Created LOs can be easily maintained, but can be very hard to update and reuse in the future. Following these simple development strategies, the created LOs in low cost structures can only satisfy the low level quality checking. At the end of the development stage, an open source LCMS may be used in this structure for storing and managing created LOs.

4.3.2 Learning Content Development: High Cost Structure

In a high cost structure, learning content development involves the cooperation of development personnel. The development process is divided into various parts: Each employee takes care of his own part, and thus makes the creation of LOs in the high cost structure into flow production process. Figure 4.6 illustrates the learning content development process in a high cost structure.

Firstly, based on the determined learning objectives, subject matter experts select learning materials and sort these materials into different folders on the computer. Authorized learning resources may be added to increase the quality and learning outcomes of learning content. Subsequently, detailed design documents and selected learning materials are passed onto the programmers and graphic artists. The programmer handles the scripting, coding and web editing, whilst the graphic artists create or modify learning materials to match the desired interactivity level of the LO.

Commercial software is widely used to accelerate the development process in this phase.

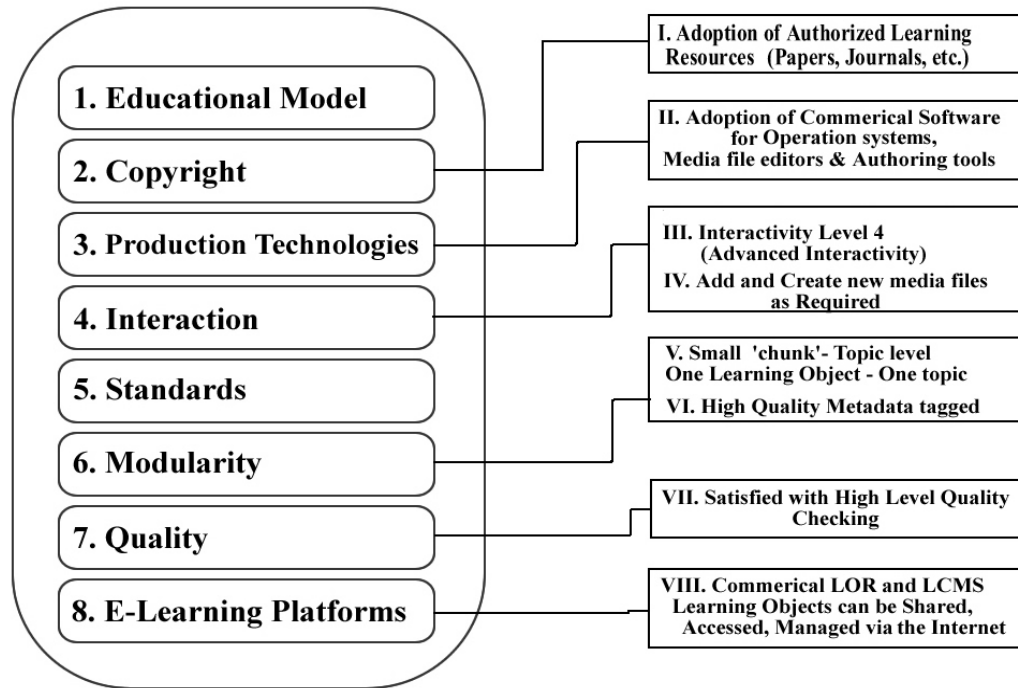


Figure 4.6: Learning Content Development - High Cost Structure

To attract learners, LOs created via the high cost structure are normally at interactivity levels of 3 or 4. These LOs contain a lot of interactive files to increase the engagement between the learning content and learners. Flash, as an important interactive file format, is widely adopted in the components of the LOs [37].

To ensure that the created LOs can be reused in other projects or for learning purposes, the granularity of a LO in this structure is designed in small 'chunks' of learning material and narrowed down to the topic level. Moreover, high quality metadata is tagged to each LO by the content author during the LO production. This metadata not only enables quick search, location and retrieval of LOs in the future, but also enhances the interoperability between the LOs and e-Learning platforms such as LOR, LMS and LCMS.

After the content author produces and packages all the LOs, created LOs are passed to quality assurance personnel for quality checking. Quality inspection for these LOs is

very strict: These LOs should be shared between specific LCMSs and LMSs, and accessed through different web browsers. For facilitating the reusability and management of LOs, the database specialist imports created LOs into a central LOR. This LOR connects to the Internet, so content providers can access these LOs via the network anytime and anywhere.

At the end of the development process, subject matter experts retrieve the LOs from the LOR based on the syllabus, and combine them into content aggregation packages, such as a lesson or a course, by using a LCMS. These content aggregation packages are then ready to be published and delivered to learners.

4.4 Learning Content Publication and Evaluation Process

During learning content publication, an e-Learning platform that consists of hardware and software is setup. An e-Learning course that integrates course content with related practices is created on the LMS and released to target learners. As soon as the online course is published, an evaluation that focuses on learners' learning processes and outcomes is implemented. The flowchart of the learning content publication and evaluation process is illustrated in Figure 4.7.

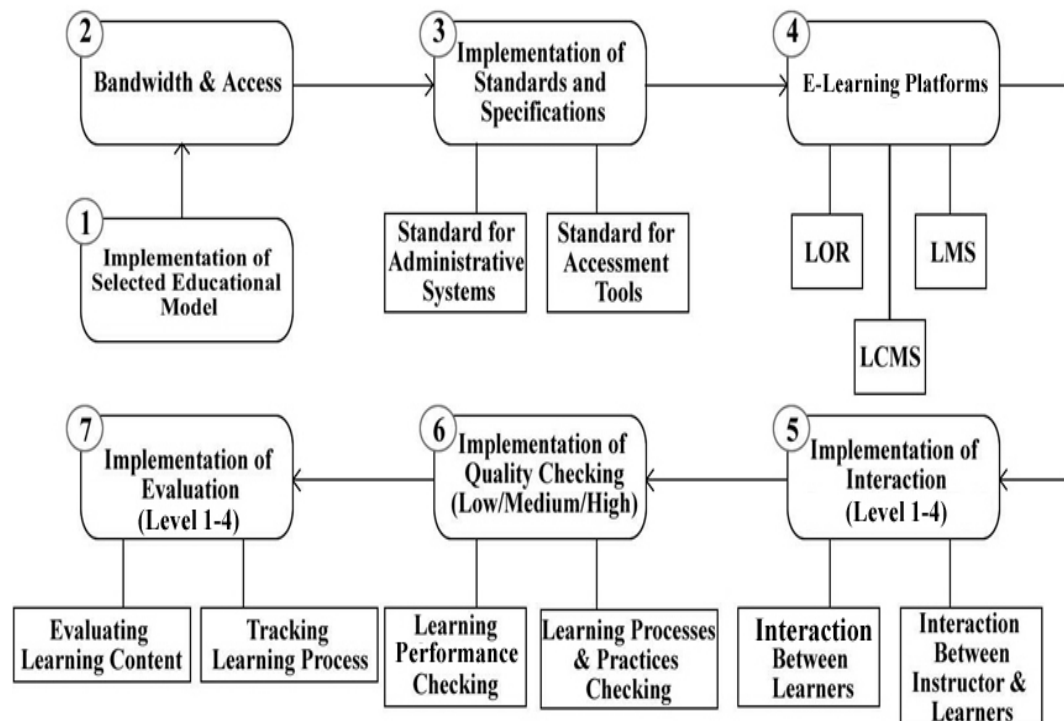


Figure 4.7: Learning Content Publication and Evaluation Process

In fact, the whole process of learning content development is based on the selected educational model. Therefore, the publication and evaluation of learning content also follows that same selected educational model. Due to target learners accessing e-Learning courses through the Internet, the bandwidth and access technology should be taken into account before establishing the e-Learning platform. The estimation of the required bandwidth should be based on the number of target learners. High bandwidth can reduce the latency of learning content download and thus provide a better learning experience for learners.

After the bandwidth is determined, an integrated e-Learning platform is built for publishing the e-Learning course. Typically, this e-Learning platform includes a web server that accept learners' requests and responds with the required course content, a database that provides functions for organizing the collection of data, and a LMS that offers virtual learning environments for instructors and learners. Recently, LOR and LCMS were also added to e-Learning platforms to complete the functionality of LO management.

Based on the detailed design documents, subject matter experts create an e-Learning course on the LMS and import related content packages into the course. After the learning content is placed on the LMS, an interactive learning environment which includes learning activities and practices is built to enhance learning experiences and facilitate learning outcomes. Normally, this learning environment provides an internal email system that allows learners to communicate with each other and with instructors. Forums, Frequently Asked Questions (FAQs) and videoconferencing may also be created in the environment to achieve the desired educational outcomes.

Before releasing online courses to target learners, the quality assurance technician will check the quality of the whole course to ensure its reliability and practicability. The inspection checks learning processes and practices, and learning performances. After quality checking, the online course is published and released to target learners. Meanwhile, the evaluation mechanism starts to track the learning progress of each learner and collects sufficient data on learning outcomes assessment. These statistics and assessment results can be used to evaluate the quality of the learning content.

From the above discussion, the identified variables involved in this process are: Educational model, bandwidth and access technology, standards, e-Learning platform, interaction, and quality and evaluation. In addition, based on different project budgets, the development strategies for these variables could be different. Therefore, possible development strategies for a given variable could be presented by analyzing the high and low cost structures.

4.4.1 Learning Content Publication and Evaluation: Low Cost Structure

In the low cost structure, the e-Learning course should be delivered to target learners at a minimum cost. Therefore, the adopted development strategies aim to reduce the cost of content publication and evaluation. The possible strategies for the identified variables are illustrated in Figure 4.8.

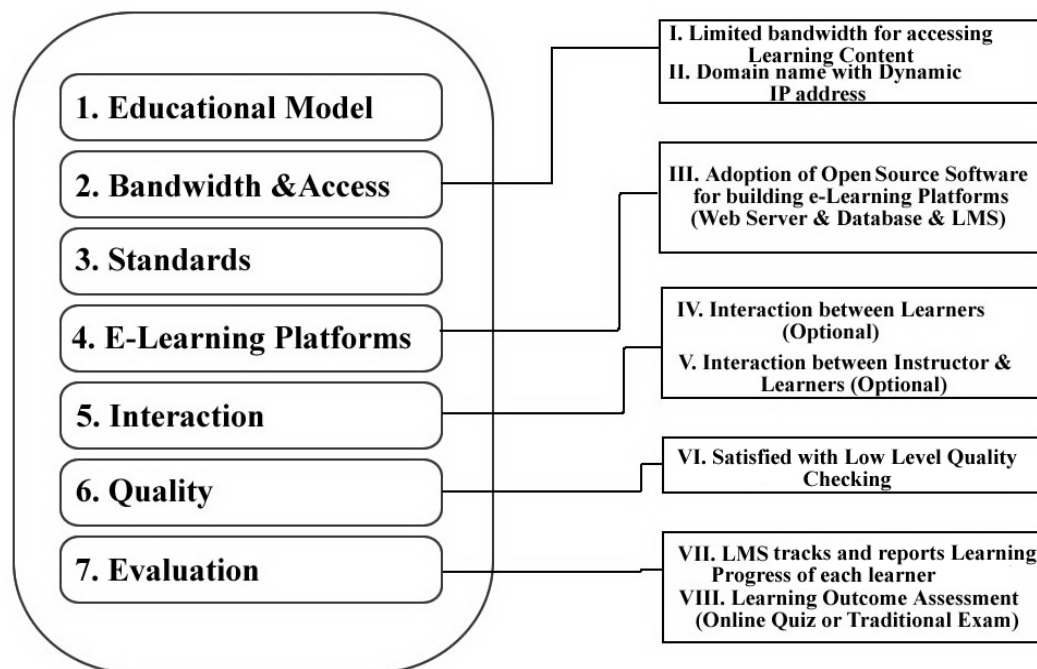


Figure 4.8: Learning Content Publication Process - Low Cost Structure

Because of limited budgets, there are few choices for the variables involved. To save on the development cost, popular broadband technologies such as a cable modem and Asymmetrical Digital Subscriber Line (ADSL) are used to connect e-Learning servers to the Internet to provide access services to the online courses over limited bandwidth. Because IP addresses are assigned dynamically in some broadband technologies, a

dynamic Domain Name System (DNS) is needed to redirect the static domain name to a dynamic IP address.

Moreover, open source e-Learning platforms are widely adopted in this structure. This open source platform, which satisfies the minimum requirements for learning content publication, includes a web server, a database and a LMS. After the e-Learning platform is established, subject matter experts choose related LOs to build the online course. Because the granularity of created LOs in a low cost structure are large ‘chunks’ of learning materials such as a lesson or a course, subject matter experts can easily organize the selected LOs into learning sequences on their own computer, and then import them into the LMS in the required learning order via the Internet.

After the course content is imported, virtual learning environments should be created. In low cost structures, building an interactive learning environment depends on the subject matter expert and the selected LMS. Although some open source LMSs offer functions to enable subject matter experts to build an interactive learning environment, development cost and time is still required. In addition, the core work in the low cost structure is to ensure the publication of the e-Learning course, thus the quality inspection process focuses on the accessibility of the course content.

In this low cost structure, the evaluation concentrates on the learners’ learning outcomes. Online quizzes and traditional examinations are two common ways used to assess the learners’ obtained knowledge. The statistics recorded by the LMS are also used for evaluating the participation of each learner in the course.

4.4.2 Learning Content Publication and Evaluation: High Cost Structure

In contrast to the low cost structure, the publication of learning content is very circumspective in this high cost structure. Because of a larger budget, the goal of the high cost structure is to create an e-Learning course with a comfortable learning environment for target learners. To achieve this goal, possible strategies for the identified variables are depicted in Figure 4.9. The adopted development strategies in this structure not only consider the quality of the e-Learning course, but also the quality of the interactive learning environment.

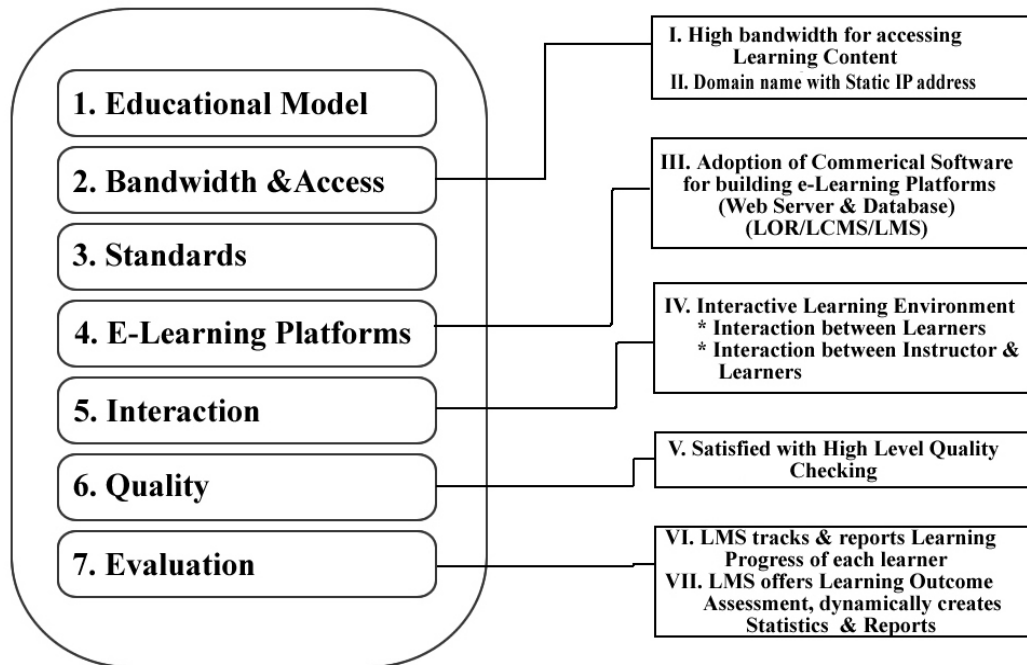


Figure 4.9: Learning Content Publication Process - High Cost Structure

In the high cost structure, a leased line offers quality access services when a large number of learners access the learning content during peak hours. High bandwidth access can reduce the latency when learners access interactive learning content to thus provide a better learning experience. An easy-to-remember domain name with a static IP address can also offer a shortcut entrance for accessing online courses.

Commercial software should be widely adopted for building e-Learning platforms in this structure as these software packages provide flexible functionality for publishing e-Learning courses. Typically, an integrated e-Learning platform includes a web server, database, LMS, LCMS and LOR. Similar to learning content development, learning content publication in the high cost structure consists of various steps that enable the flow of operations that involve employees.

Firstly, the subject matter expert prepares the syllabus of the e-Learning course and related content aggregation packages. Based on the syllabus, the webmaster creates an e-Learning course on LMS and imports the content aggregation packages into the course. Subsequently, the webmaster starts to add learning activities and practices into the course, and then builds an interactive learning environment to enhance the learning

experience. This interactive learning environment not only provides tools such as a virtual classroom and online chat to enable interaction between learners, but also offers functionality such as videoconferencing, forums, and FAQs to enable interaction between the instructor and learners.

Before publishing the online course, the quality assurance technician carefully inspects the whole e-Learning course and learning environment. Finally, the e-Learning course is released to target learners. During the learning process, LMS tracks the participation of each learner and creates a learning progress report.

Moreover, along with the learning process, LMS offers different assessments to evaluate the learners' learning outcomes; these assessments include online quizzes, critical thinking tasks, and individual and group assignments. LMS dynamically creates statistics based on the results of these assessments. Through analysing the statistics and reports, the subject matter expert can improve course content and related practices to thus promote the quality of the e-Learning course.

4.5 Prioritizing the Variables Influencing the Cost of Learning Content Development

By analysing the flowcharts of the three main content development processes and discussing two extreme cost structures that could be adopted in each process, the extent of each variable's impact on the entire learning content development process is measured. Based on the significance and logical relationships of identified variables in the learning content development process, identified variables are prioritized as:

- | | |
|------------------------------------|----------------------------|
| 1. Educational Model | 2. Standards |
| 3. E-Learning Platforms | 4. Production Technologies |
| 5. Bandwidth and Access Technology | 6. Interaction |
| 7. Modularity | 8. Evaluation |
| 9. Quality | 10. Copyright |

Variables listed above are mostly relevant to conditions exist in Australia. Due to the dissimilar social and economical factors in different countries such as technology, infrastructure, working conditions, the sequence of prioritized variables could change. To expand the scope of the work, social and economical factors in other countries

should be taken into account. For instance, labour costs in many Asian countries are much lower than Australia. This will have an impact on design and development of learning content. And also, in few countries issue of copyright is not as important as Australia.

4.5.1 Educational Model

Because the entire learning content development process is based on the selected educational model, the educational model is prioritized first in the identified variables. The educational model not only provides the infrastructure for content development, but also specifies the delivery methods for publishing the learning content. If the same educational model is not used to design, develop and publish learning content, created learning content may have usability problems. For example, if the selected educational model specifies a Compact Disk (CD) or Digital Video Disk (DVD) as the content delivery medium for learning content design, the designed learning content may be large files and thus the created learning content will not be delivered through the LMS.

4.5.2 Standards

‘Standards’ is another variable involved in the entire learning content development process, thus it is prioritized second to the educational model. Following standards to design and develop learning content, the standards-conformant content can thus be shared and exchanged between different standards compliant e-Learning platforms. No extra investments or efforts in modifying or converting the created learning content are needed, thus the reusability of the learning content is enhanced. Moreover, the selection of suitable standards also influences the purchase of production and publication applications, which are the major investments in learning content development.

4.5.3 E-Learning Platforms and Production Technologies

Normally, more than half of the content development costs are spent on the production and publication technologies. Therefore, e-Learning platforms and production technologies should be prioritized following the standards variable. Choosing the most appropriate e-Learning platform and production tools for learning content development can accelerate the development process and thus result in considerable savings in the development cost. In addition, as an important component of e-Learning, the investments in e-Learning platforms are noticeable: These e-Learning platforms may

initially charge according to the total number of learners, but charges will continually increase through annual server maintenance and technical support. In this case, selecting a suitable e-Learning platform is more important than the selection of the production technologies.

4.5.4 Bandwidth and Access Technology

In contrast to other content development projects, learning content created for WBT is delivered to target learners via the Internet. Therefore, bandwidth and access technology is a primary factor in the content design and publication of e-Learning resources. To avoid long download delays for the learners, available bandwidth should be estimated when designing the learning content as it will constrain the size and interactivity level of the learning content. Moreover, for learning content publication, investment in a high bandwidth connection between e-Learning servers and the Internet is required: High bandwidth can provide a good learning experience to the learners and thus enhance the effectiveness of the learning content.

4.5.5 Interaction

In WBT, high quality interactive learning content and learning environments can facilitate positive learning outcomes by attracting and maintaining the learners' attention. To design and develop an interactive e-Learning course, significant investments in interaction and graphic design are needed. Content developers may create new audio, video and animation files to achieve the high interactivity level, thus the development costs depend on the interactivity level of the designed learning content. In fact, available bandwidth can be considered as a guideline when determining the interactivity level of the learning content.

4.5.6 Modularity

After the interactivity level of learning content is decided upon, the modularity of each LO should be determined where the modularity of a LO includes its granularity and metadata. The granularity of a LO is affected by the available bandwidth and interactivity level. If a LO is designed as a large 'chunk' of learning content, it is difficult to deliver the created LO to learners via the limited bandwidth and have the LO reused in the future. On the other hand, if a LO is designed as a small 'chunk' of learning content, the size of the LO constrains its interactivity level, but it is easier to

reuse the LO in the future. Further, determining the suitable granularity for each LO can enhance the reusability of the created learning content and hence reduce the development cost.

4.5.7 Evaluation

Evaluation is an important part of learning content development. Due to the variation of investments and budgets among content development projects, the evaluation level and relevant costs could be different. In ‘bronze’ projects, online courses are an extension of the existing classroom. Assessments in an online course can be considered as method that assists to enhance learning outcomes. However, in ‘platinum’ projects, evaluation is an indispensable step of content development: The statistics and reports of evaluation could indicate the effectiveness and efficiency of the created learning content. Advanced educational models or new learning theories can then be developed by summarizing the evaluation results.

4.5.8 Quality

During learning content development, quality control and inspection of the created learning content is required. The cost of the quality inspections depends on the quality checking level and methods. In ‘bronze’ projects, quality checking is normally implemented by instructors who simply preview created learning content before releasing the content to learners. However, in ‘platinum’ projects, learners may need to pay for permits to access online courses, thus any access problems and errors in the created learning content will incur complaints from learners. In this case, quality control and inspection during the entire learning content development process should be very strict in these projects. It is obvious that selecting suitable development strategies for identified variables can improve the quality of the created LOs.

4.5.9 Copyright

Adopting authorized learning resources can improve the quality of the learning content and affect positive learning outcomes. However, the selection and utilization of authorized learning resources are decided upon by instructional designers, thus the costs for purchasing licences or obtaining the copyright permissions of these resources is difficult to estimate. Moreover, to protect the created learning content, many digital copyright and licensing applications may be used. Because the typical LMS provides a

registration and authentication system to administrators, these applications have become an alternative for instructional designers. Thus, copyrights have less of an impact on the costs of learning content development.

4.6 Conclusion

In brief, this chapter discusses the relationships between the identified variables and the learning content development process. By analysing the flowcharts of the three main learning content processes, possible development strategies for the identified variables in two cost structures are introduced. Finally, based on the extent of each variable's impact on the entire learning content development process, identified variables are thus prioritized. In the next chapter, a cost-effective content development model which consists of the identified variables is introduced.

CHAPTER 5. LEARNING CONTENT DEVELOPMENT TARGET MODEL

After the identification and prioritization of variables that influence the cost of learning content development, the feasibility of constructing a cost-effective content development model emerges. As mentioned in previous chapters, the concept of the Learning Object (LO) indicates a possible way to create cost-effective learning content. Therefore, the core of the target cost-effective model should focus on developing learning content as Reusable Learning Objects (RLOs). Moreover, the investigation of two extreme cost structures demonstrates that assigning suitable development strategies to controllable variables is another mature solution for minimizing the development cost and forming the target cost-effective model.

This chapter presents a cost-effective content development model with a configurable structure that helps in the design, development and publishing of cost-effective RLOs. Getting started with the analysis of the identified variables, controllable variables are extracted for constructing the target model. The construction of a cost-effective model utilizes the three main content development processes introduced in Chapter 4: The basic structure of the target model is built by simply selecting development strategies from either the high or low cost structure for the given variables in each process. Finally, the components of the proposed cost-effective content development model, which includes refined narratives of the development strategies for the identified variables, are introduced in detail.

5.1 Extracting Controllable Variables for Constructing the Target Model

It is clear that not all of the identified variables are controllable. As mentioned in the early stages of the research work, some identified variables contain parameters that are unpredictable and uncontrollable, hence the costs of these parameters are hard to detect and estimate; these 3 variables and 8 parameters are shown in Table 1.1. Because the target cost-effective model tries to minimize the cost of learning content development, these variables and parameters are excluded from the construction of the cost-effective model. This section provides brief explanations on the extraction of the controllable variables where the extraction is achieved by a thorough analysis of the identified variables.

Due to the different objectives and existing resources in different learning content development projects, the cost of the required resources is unpredictable and very hard to estimate. In addition, most content development projects adopt existing educational models for the design, development and publishing of learning content, hence investing in the design of learning theories and models is not required in every learning content development project. Therefore, 'required resources' and 'pedagogy' are considered as uncontrollable variables and are thus excluded from the construction of the target cost-effective model.

Although authorized learning resources may be adopted to improve the quality of the LOs, the cost of using these copyright resources is hard to compute. In fact, adopting authorized learning resources is not necessary in every content development project, thus 'copyright' as a variable that has less of an impact on the cost of learning content development is also excluded from the target cost-effective model.

However, to provide the infrastructure for learning content development, the selection of a suitable educational model and standards can lead to significant savings in development time and cost. Obviously, the educational model and standards are decided upon by instructional designers, thus these two variables can be considered as controllable variables. Moreover, to produce and publish learning content, computer hardware and software are required. Owing to the fact that cost of computer hardware and basic software packages such as operating systems are very hard to estimate, the cost minimization should focus on reducing the investment in authoring tools and e-Learning software platforms.

For publishing online courses, a broadband connection between the e-Learning server and the Internet is needed. Normally, the selection of an appropriate access technology depends on the budget of the content development project, where the cost of the broadband connection is charged monthly by the Internet Service Provider (ISP). Because the selected access technology is hard to detect, the available bandwidth offered by popular access technologies should be considered as a guideline for designing learning content in the target cost-effective model. Suitable sizes for the created LO and its media files can improve the accessibility of the learning content and reduce the redundant efforts required for modifying LOs for different bandwidths.

Furthermore, the cost of learning content development may be directly influenced by the LO's interactivity level and modularity. Therefore, successful instructional design can enhance the reusability of the created LOs and decrease the development cost. In addition, designing effective evaluation and quality inspection mechanisms can also reduce the development cost. It is obvious that the target cost-effective model should make an effort to minimize the development cost of these controllable variables.

5.2 Minimizing the Cost of Learning Content Development

After analysing the identified variables, controllable variables are then extracted. These variables can affect the content development cost from different aspects; therefore, selecting suitable strategies for these variables is a potential way to minimize the cost of learning content development.

As discussed in Chapter 4, the high and low cost structures present two extreme scenarios that consist of different development strategies that can be applied to the identified variables. The basic structure of the target cost-effective model can be built by simply selecting development strategies from either the high or low cost structure. However, the target cost-effective model must balance cost minimization and quality of the LOs. Therefore, the final proposed model might incline towards to one of the extreme scenarios, rather than being an average of the two.

The following section will describe how to construct the basic structure of the target cost-effective model by choosing suitable strategies from the high and low cost structures. Rational and logical links are drawn to show the direct consequences between the refined and prioritized variables and elements of the two scenarios. The basic structure of the cost-effective model covers three content development processes: Planning and design, development, and publication and evaluation.

5.2.1 Cost Minimization: Learning Content Planning and Design

In the design process, development strategies for controllable variables should be determined and used to lead subsequent content development steps. As part of the infrastructure of learning content development, the educational model and standards should be selected first. Rather than design and develop a new model, the distributed

learning model which has been widely used in both the high and low cost structures can be directly adopted for the cost-effective model.

Moreover, SCORM, as the most popular content component model, should be selected as the basic standard for content development and packaging. According to ADL, there were 187 e-Learning products supporting SCORM 1.2 and SCORM 2004 standards at end of 2006 [50]. SCORM-compliant content can work with every conformant LMS, thus the reusability of SCORM-compliant LOs can be enhanced and ensured.

Another alternative solution for reducing the development cost is to adopt Open Source Software (OSS) packages to create and publish learning content. These software packages not only provide similar functions as commercial software packages, but are also free to download and use, which can reduce the development cost to a minimum level. Due to more than the half of development cost being spent on purchasing related production and publication technologies, the adoption of OSS for content authoring and building of the e-Learning platform can result in considerable savings on the development cost.

The learning content development project may be initiated by the subject matter experts. For further savings on the development cost, the subject matter expert may establish e-Learning platforms with a second-level domain name bound to a dynamic address, or build on an existing server with a static IP address. Both situations should be considered in the cost-effective model and respective solutions should be provided.

Furthermore, each LO should be designed as a small ‘chunk’ of learning content that focuses on one learning objective. This strategy may increase the development cost, but narrowing the granularity of the LO down to the topic level can decrease the size of each LO, and thus enable easy reuse and delivery through different bandwidths. In addition, high quality metadata should be tagged to each LO: LO integrated with high quality metadata enable content authors to manage, search, retrieve and reuse the LO, hence avoiding repeat LO creation and saving the development cost. Figure 5.1 illustrates how to construct a cost-effective model by selecting suitable development strategies for the controllable variables in the learning content design process.

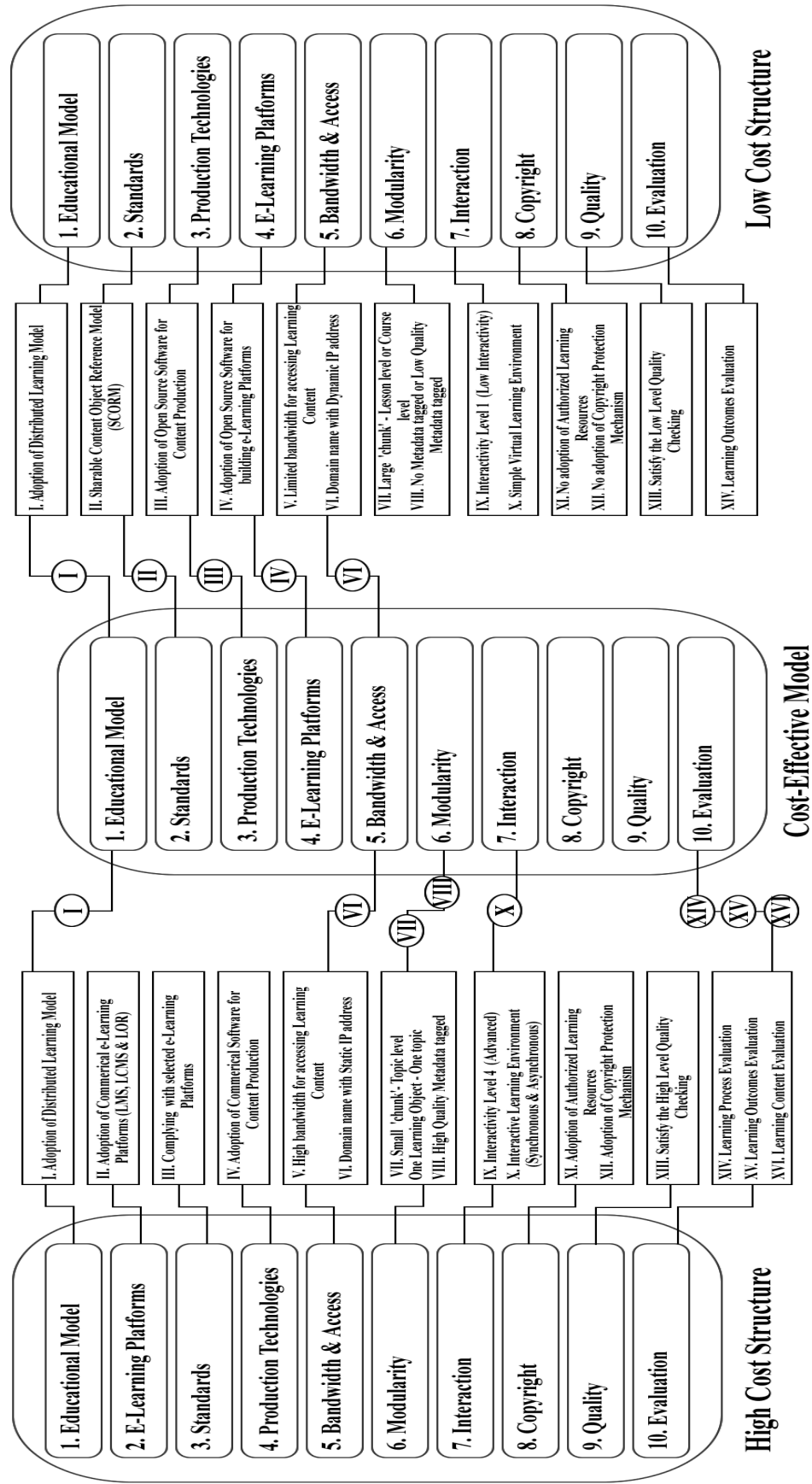


Figure 5.1: Selecting Suitable Development Strategies for Controllable Variables in the Learning Content Planning and Design Process

In contrast to traditional learning environments, a virtual learning environment is required for publishing the e-Learning course. Currently, most lecturers in tertiary education use LMS to release their subject notes. As a result of limited development costs and knowledge about using LMS, simple learning environments are normally created. Students usually browse and download lecture notes from the learning environment without taking part in any learning activity. However, as an indispensable part of e-Learning, it is worth while spending the time and effort on creating an interactive learning environment for an e-Learning course. Interactive learning environments can encourage learners to participate in learning activities, hereby enhancing learning experiences and facilitating learning outcomes.

To evaluate created LOs, relevant data should be collected during the learning process including learners' feedback and time spent on each LO. In fact, most LMSs will record data in their background database during the learning process and create the corresponding statistics when required by the course instructor. Moreover, the LMS also provides functional modules for implementing learning outcomes assessment; therefore, no extra costs or efforts are needed to design the evaluation methods.

5.2.2 Cost Minimization: Learning Content Development

Generally, the content development process executes the detailed design documents that were formed in content design process. Development strategies for the controllable variables involved in this step were decided upon in the design stage, and these variables include the educational model, production technologies, standards, modularity and e-Learning platforms.

OSS packages are widely used in the development stage for producing LOs and cutting development costs. These software packages include operating systems, web editors, media file editors, authoring tools and e-Learning software platforms. However, although open source e-Learning software platforms are free to download and use, most content authors rarely use them for content development. In fact, adopting LOR and LCMS for managing and aggregating LOs can improve the efficiency of content development. Selecting development strategies for the controllable variables to construct a cost-effective model in the learning content development process is shown in Figure 5.2.

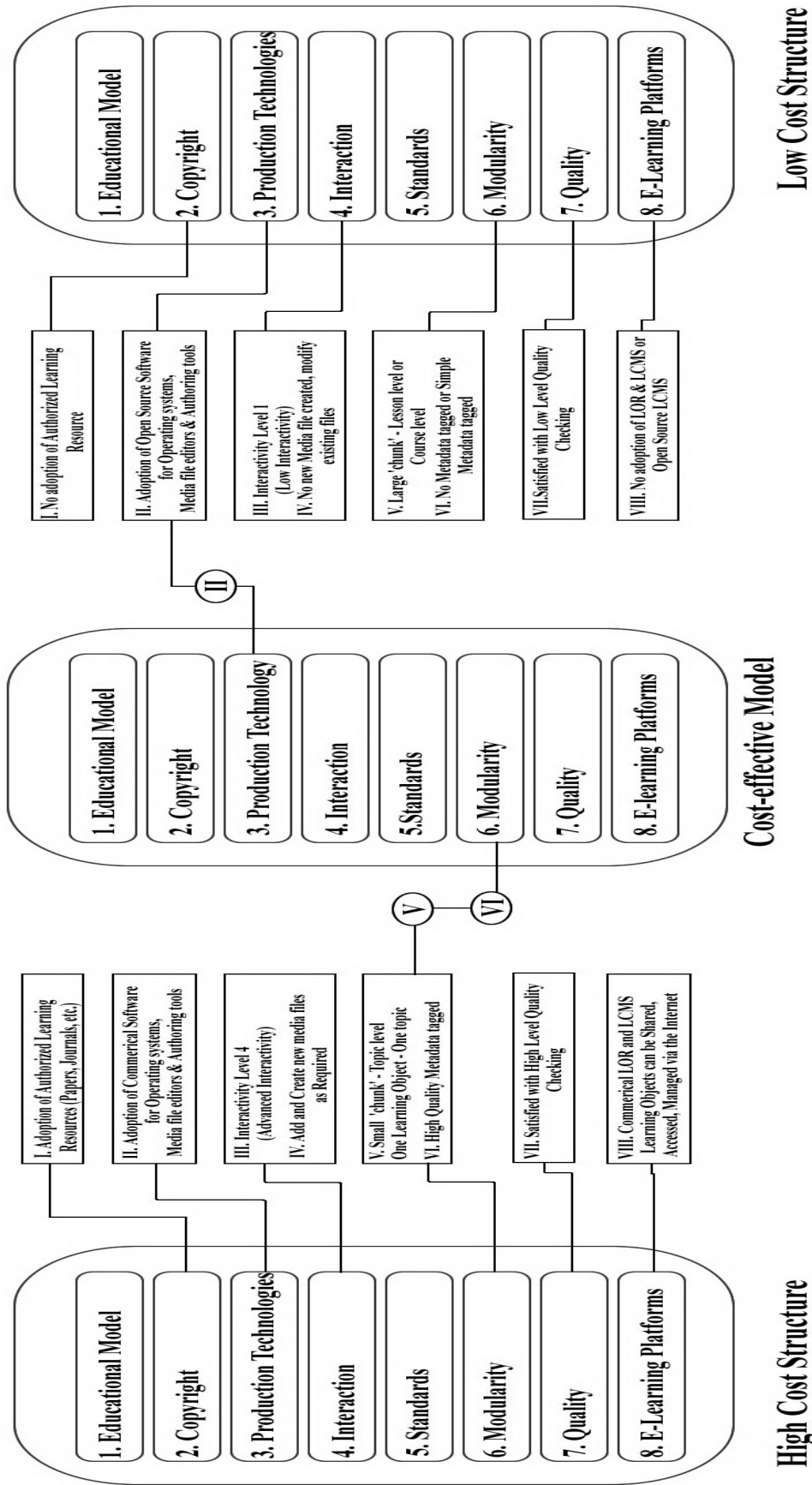


Figure 5.2: Selecting Suitable Development Strategies for the Controllable Variables in the Learning Content Development Process

5.2.3 Cost Minimization: Learning Content Publication and Evaluation

Development strategies for the controllable variables in the content publication stage are also determined in the content design process. The main jobs in this phase are following these strategies to create online courses and publish related LOs. Within the adopted strategies, two efficient approaches that indicate potential for reducing the cost of content publication and evaluation should be highlighted.

One solution for decreasing the development cost is to comply with a low cost structure that uses OSS for learning content publication. A unified e-Learning platform can be built based on these OSS packages, which normally includes a web server, database, LOR, LCMS and LMS.

Another efficient way is to utilize LMS for implementing the evaluation. LMS can be used for tracking and reporting the learning progress of each learner who is enrolled in the online course. Relevant assessments should be created and released on the LMS to evaluate learners' learning outcomes. Based on the assessment results, the LMS can dynamically produce statistics and reports, thereby enabling independently instructors to evaluate LOs. Figure 5.3 shows how to select suitable development strategies for the controllable variables in the learning content publication and evaluation process.

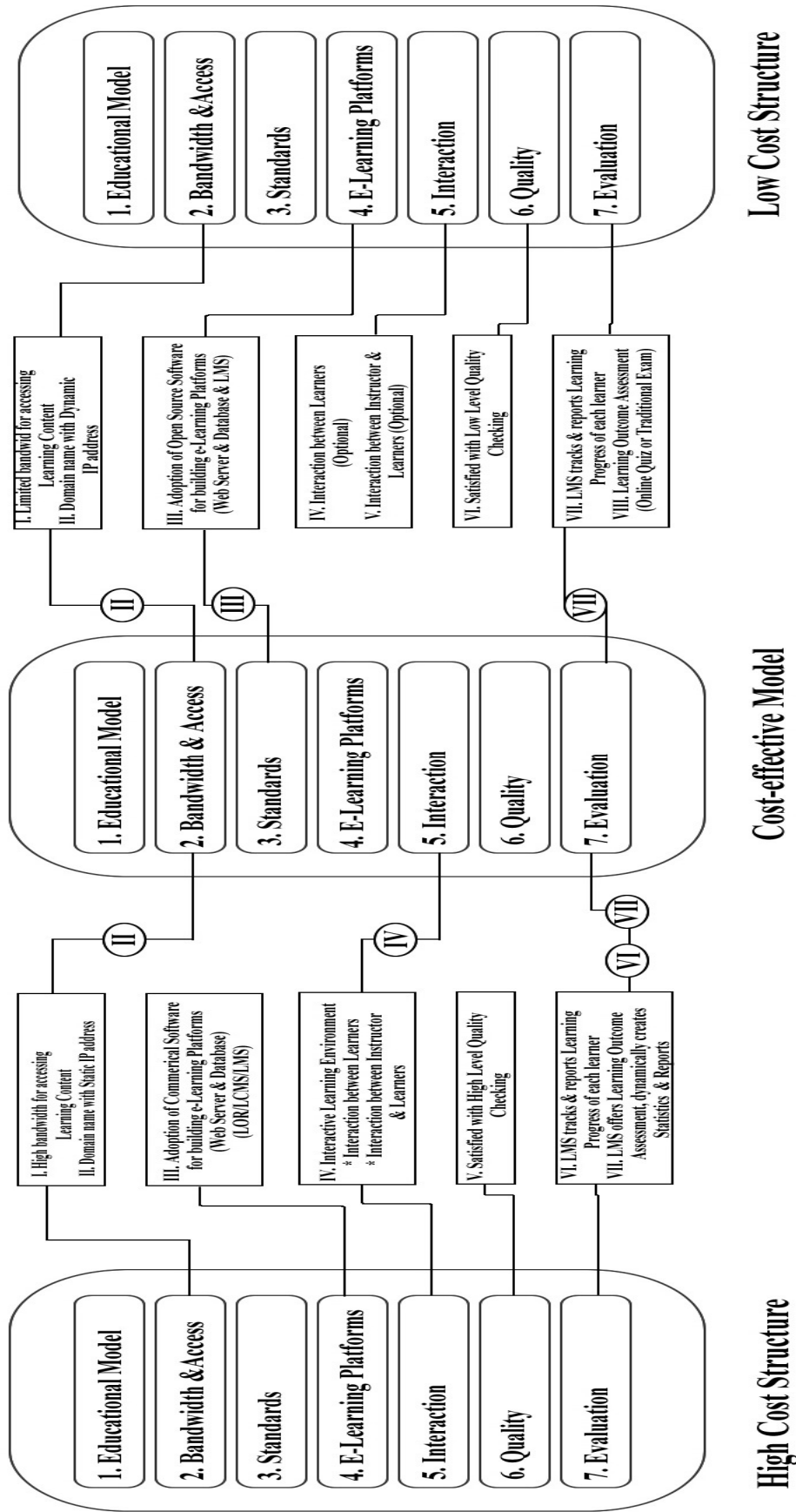


Figure 5.3: Selecting Suitable Development Strategies for the Controllable Variables in the Learning Content Publication and Evaluation

5.2.4 Cost Minimization: Adoption of Open Source Software in the Cost-effective Model

After selecting useful development strategies for the controllable variables from the two extreme scenarios, the basic structure of the cost-effective content development model is formed. To obtain the development model, a refined description should be empirically added to those variables that cannot match the development strategies in both the high and low cost structures.

However, from the basic structure of the cost-effective model, it is easy to see that adopting OSS packages for learning content development could be an efficient way to cut down on the development cost. Therefore, how to choose the most appropriate software packages becomes a key factor in the cost-effective model. Adopting OSS for learning content development is not a new initiative in tertiary education. Free download, use, modification, and redistribution of OSS packages make them attractive to consumers. In fact, some lecturers have already used OSS packages to prepare their teaching materials using tools such as a flash creator and PDF converter.

As the LO is a new concept in learning content, the various standards and tools of LO are confusing to content authors who are interested in developing cost-effective learning content. Hence, authors may prefer commercial software packages with technical support compared to OSS packages, which can lack in technical support.

In fact, there are some OSS packages that provide similar functions to commercial software packages. These standards compliant software packages can be used for creating and publishing LOs. The following paragraphs will introduce some of the OSS packages that are related to learning content development and can be adopted in the target cost-effective model. These OSS packages can be treated as examples that help the content author to select their development tools when they are using the proposed cost-effective model.

- *Authoring tools*

Reload Metadata and Content Packaging Editor [51]: Reload Editor is an open source authoring tool. By using this editor, the user can organize, aggregate and pack LOs into

IMS and SCORM standards compliant content packages. Reload Editor also provides functions for editing and managing metadata within the content packages; this editor can thus be used to encapsulate existing web-based learning content into standards conformant LOs [51].

CourseLab [52]: CourseLab is a free authoring tool that offers a programming-free WYSIWYG environment to assist teachers to develop web-based learning content [52]. Through CourseLab, existing PowerPoint slides can be quickly converted into standards conformant LOs.

eLearning XHTML editor (eXe) [53]: eXe is a open source e-Learning authoring tool that is designed to help instructors to create high-quality interactive e-Learning content which can be published on the standards conformant LMSs. Learning resources authored in eXe can be exported in the IMS content package, SCORM 1.2 package or simple self-contained web pages [53]. Using eXe, content authors can easily create web-based interactive LOs.

- *Learning Object Repository*

Digital Open Object Repository (DOOR) [54]: DOOR is an open source LOR. Digital contents in the form of LOs can be stored, searched and retrieved in the DOOR. DOOR complies with popular e-Learning standards, and implements the IMS Metadata 1.2.1 and Content Package 1.1.3 specifications. In addition, DOOR is also fully integrated with Moodle, where the DOOR-Moodle plug-in allows instructors to browse the content repository seamlessly from a single Moodle course, and then select and import LOs into the course with their metadata [54].

- *Learning Content Management System*

ATutor [55]: ATutor is a web-based LCMS that supports SCORM 1.2 and IMS content packaging specifications. ATutor provides a built-in SCORM 1.2 RTM to communicate and manage LOs. Through ATutor, instructional designers can easily retrieve, aggregate, encapsulate and redistribute LOs. Pre-packaged content can also be quickly imported into ATutor and organized into an online course. On the other hand, ATutor offers many powerful tools as a LMS, and learners can study online courses in an adaptive learning environment [55].

- *Learning Management System*

Moodle: Moodle is an open source course management system that is designed to help instructors to create quality online courses. Moodle supports 64 languages and SCORM 1.2 standards. It provides many powerful tools which include interactive learning activity modules (e.g. chat, forum, quizzes, etc.) for helping instructors to create online courses and interactive learning environments. Moreover, through its resources management functionality, Moodle enables instructors to create e-Learning courses with a range of digital content. Furthermore, each learner's activities and progress can be tracked and reported in Moodle [32].

The OSS packages listed above provide a set of useful functions for content authoring and publication. Adopting these software packages in the cost-effective model is an effective way to create LOs whilst minimising the development cost. Furthermore, based on these software packages, an experimental platform has been built, and a case study has been carried out on this platform to provide extra information about the cost-effective model in a practical way (Chapter 6).

5.3 A Cost-effective Content Development Model

Developing learning content as RLOs, assigning suitable development strategies to the controllable variables, and selecting appropriate OSS for content development and publication are cost-effective ways to help create and distribute learning content for e-Learning. These ontological approaches can integrate with basic learning content development processes and form a cost-effective content development model.

The purpose of this cost-effective content development model is to assist higher education instructors in design, development and publishing of sustainable web-based learning content without the need to become proficient in the concept of LOs or related technologies. By following elaborate cost-effective development strategies in the proposed cost-effective model, flexible and reusable learning content with assured quality can be created. The components of the cost-effective content development model are shown in Figure 5.4.

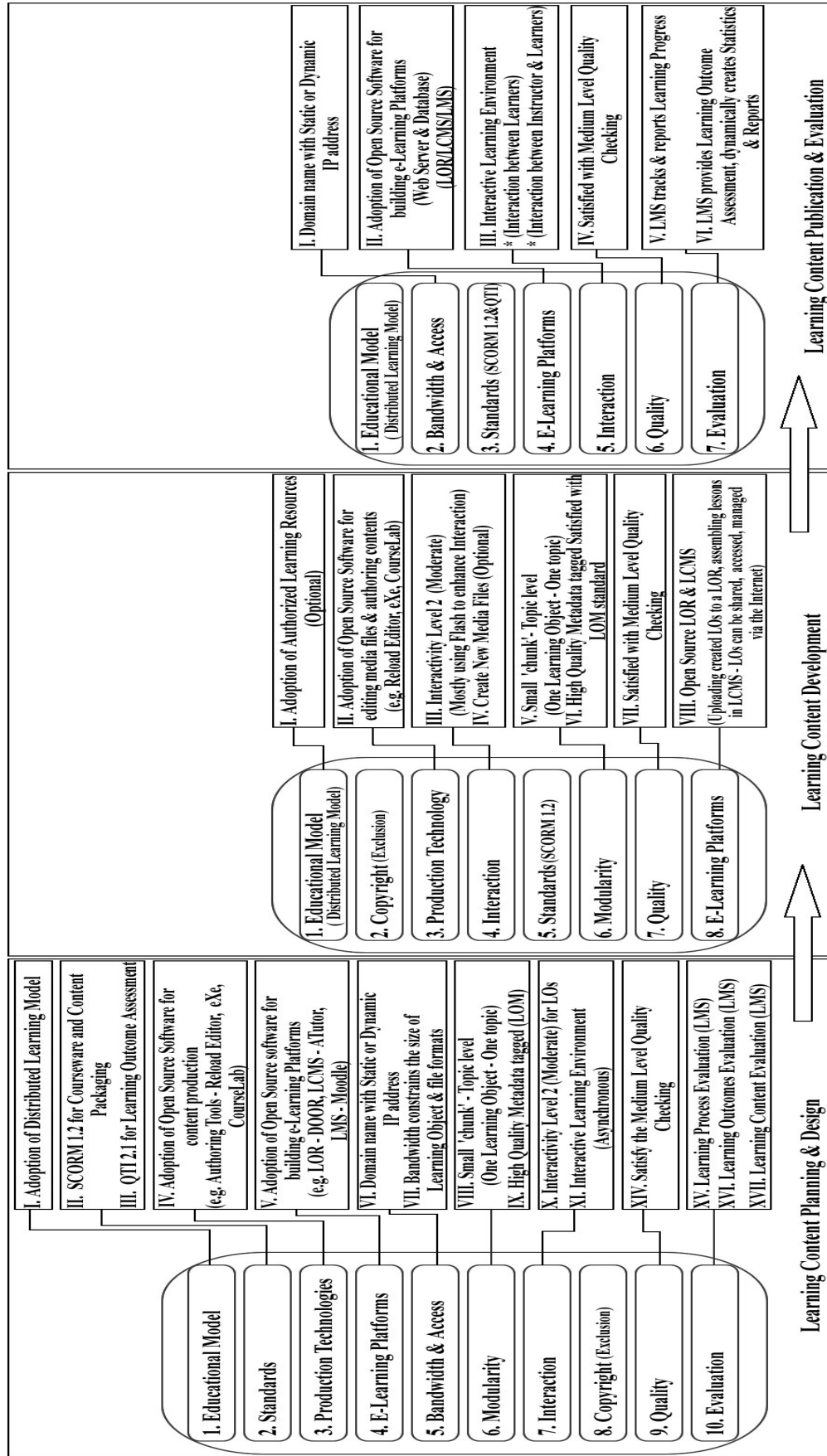


Figure 5.4: The Components of Cost-effective Content Development Model

The cost-effective content development model covers the entire learning content development process: Learning content planning and design, learning content development, and learning content publication and evaluation. The details of proposed cost-effective model are described in the following sections.

5.3.1 Learning Content Planning and Design

As the most significant phase of learning content development, design principles are inevitably involved with both technology and pedagogy. Normally, there are two types of learning content design principles: Pedagogical design principles that focus on creating learning content with effective learning experience, and structural design principles that concentrate on enhancing the potential reusability of learning content by technically organizing the content structure [56]. The proposed cost-effective content development model is inclined to the latter. Figure 5.5 illustrates the learning content planning and design process of the cost-effective content development model.

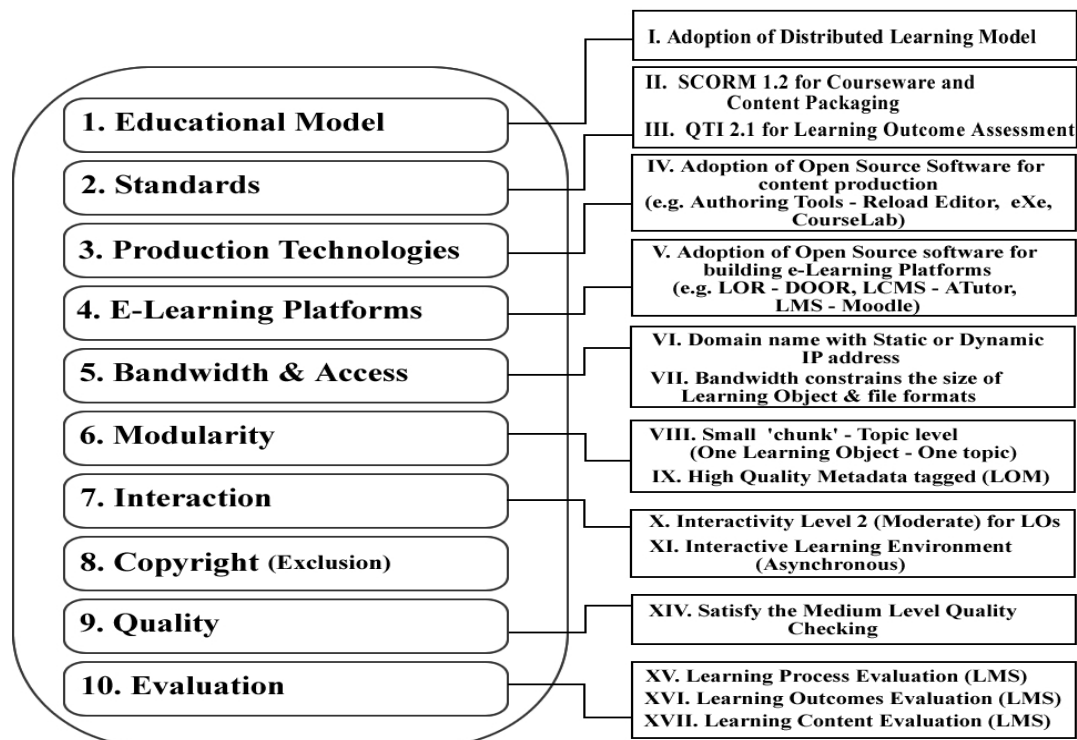


Figure 5.5: Learning Content Planning and Design Process of the Cost-effective Content Development Model

To design learning content, the educational model firstly should be confirmed. A distributed learning model is suggested as a prototype model for the entire content development project in the proposed cost-effective model. The basic structure of the distributed learning model is indicated in Figure 5.6.

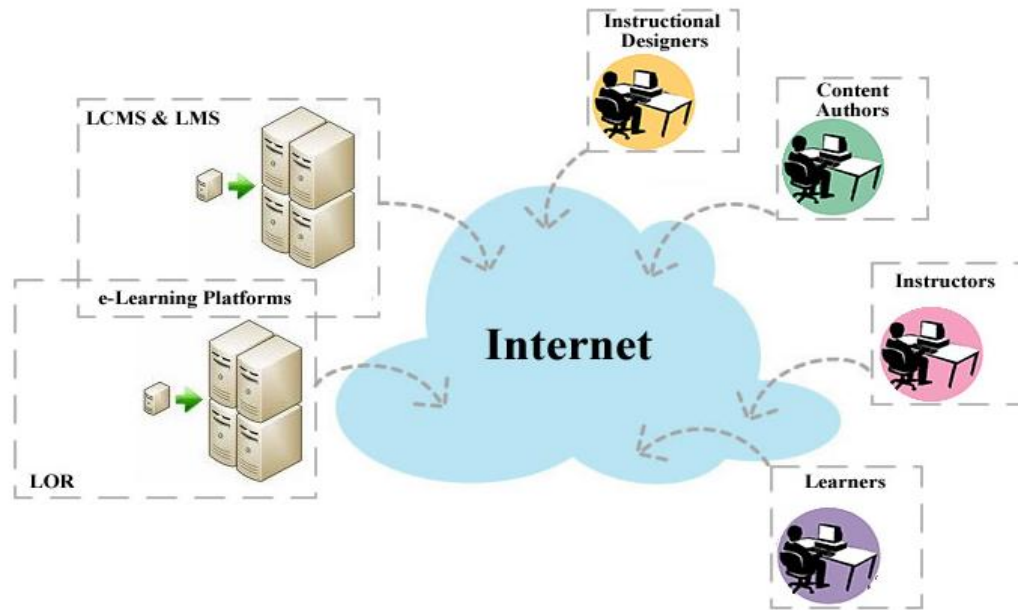


Figure 5.6: The Basic Structure of Distributed Learning Model

As shown in Figure 5.6, all components of the distributed learning model are connected through the Internet. Based on the different budgets of content development projects, e-Learning platforms can be built on one or more servers, and placed in one or more locations. Through the Internet, instructional designers and content authors can upload created LOs to the LOR and manage existing LOs. Instructors can also search and retrieve desired LOs in the LOR, using LCMS to integrate them together and distribute online courses to learners via the Internet. As these e-Learning platforms can be accessed anytime and anywhere, considerable development cost savings could result.

The proposed cost-effective content development model is based on the SCORM 1.2 standards, which contain the IEEE/LTSC LOM standard [12], IMS XML meta-data binding specifications [22], and IMS content packaging specification [20]. Though e-Learning vendors are updating their products to support SCORM 2004 3rd edition [19], SCORM 1.2 is still the most popular and stable version. By complying with SCORM

1.2, the reusability of the created LOs can be ensured and enhanced. Moreover, the proposed cost-effective model suggests adopting QTI 2.1 specifications for creating assessment questions to evaluate learning outcomes. Extra benefits could be gained every time these created LOs and assessment questions are reused.

To minimize the cost of content development, OSS packages are widely adopted in the proposed cost-effective model for producing and publishing learning content. For example, Reload Editor can be adopted for packaging LOs, CourseLab can be used for converting existing PowerPoint files to LOs, and eXe can help instructors to create new web-based learning content. Furthermore, the e-Learning platform can also be built by using OSS packages. For example, a web server could firstly be setup based upon an Apache web server [57] and MySQL database [58]. Then, DOOR, ATutor and Moodle can be installed and run on this platform. Adopting these OSS packages in the cost-effective model can reduce the cost of content development to a minimum level.

To decrease the development cost, the cost-effective model proposes two development strategies for content publication that effectively utilize existing resources. According to these two strategies, the e-Learning platform can be established on web servers with either dynamic or static IP addresses; however, to improve the accessibility of the learning content and facilitate learners' active participation, an easy-to-remember domain name for both situations is required. Moreover, dynamic DNS software is needed if the e-Learning platform runs on the web server with a dynamic IP address. There are many OSS packages or free applications that have gracefully addressed and handled the problems associated with dynamic IP addresses, such as Peanuthull [59] and No-Ip [60].

In fact, most of the broadband technologies cannot promise quality of service when learners explore highly interactive learning content during peak hours. Therefore, the proposed cost-effective model believes that the development of learning content should be constrained by the available bandwidth, including the size of each LO and the multimedia file formats within it. To obtain better learning experience with low latency from learning content download, the components of each web page should be well organized and structured. The following suggestions are proposed in the cost-effective model to solve the addressed problems. Reducing the size of each LO can be achieved

by narrowing the granularity of each LO into ‘topic’ levels, restricting the interactivity level and adopting bandwidth-friendly file formats.

The definition of a LO describes a LO as a self-contained learning module that focuses on one learning objective [14]. Normally, designing the structure of LOs would involve using appropriate pedagogy to present learning materials and achieve expected learning objectives. As the design of the LO should refer to specific learning objectives, it is hard to offer a particular model for constructing the layout of the LO. However, based on CISCO’s contribution and the SCORM CAM, the cost-effective model suggests a LO structure that can be considered as a guide for aggregating LOs into an e-Learning course (see Figure 5.7).

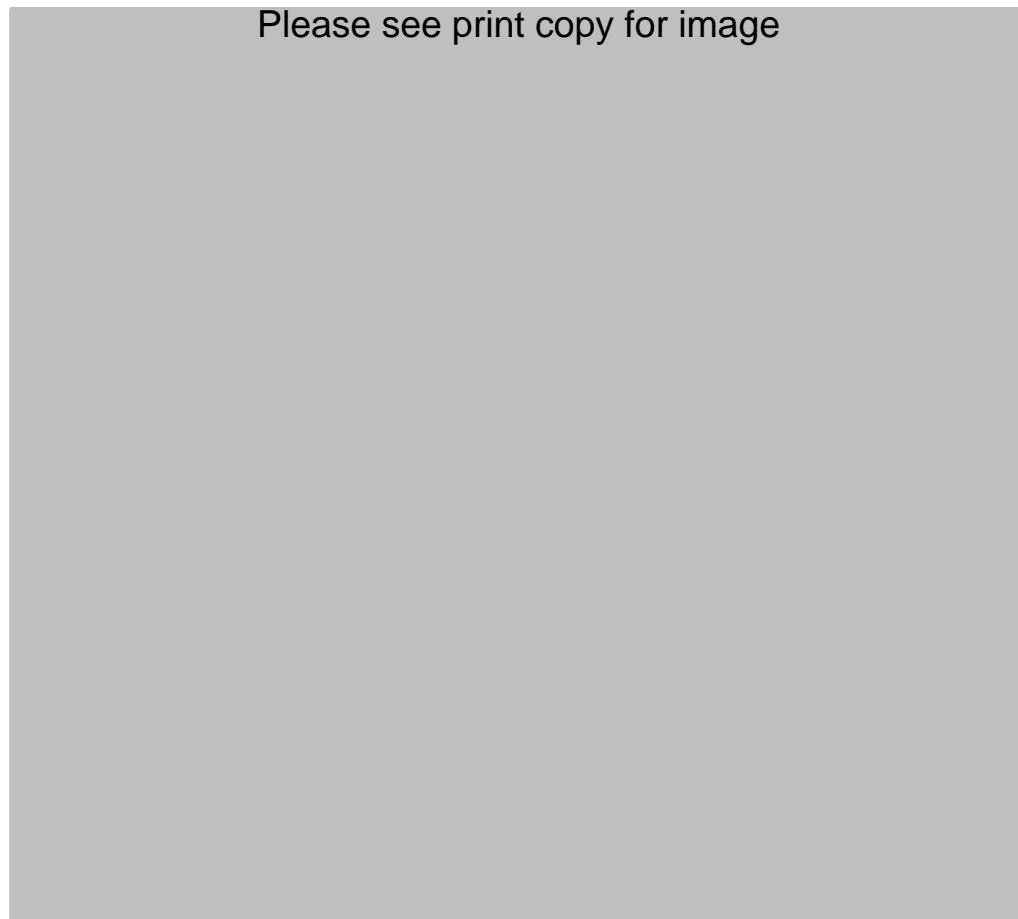


Figure 5.7: A LO Structure, according to CISCO and SCORM CAM [61]

In CISCO’s vision, a LO should be designed as a standalone learning unit that contains the essential parts and builds upon a learning objective. Moreover, CISCO and SCORM

CAM also pointed out that an e-Learning lesson can be built by combining related LOs together, whilst a complete lesson should contain an overview, five to nine theory modules (LOs), a summary, activities and assessments [61].

In addition to reduce the granularity of each LO into lower levels, restricting the interactivity level is another effective way to decrease development costs and ensure quality of service during peak access hours. The proposed cost-effective content development model suggests that interactivity level for each LO should satisfy interactivity level 2 (see Section 3.1.4). Normally, content authors have enough learning materials to create LOs that match the interactivity level 2. Designing LOs with moderate interactivity levels not only saves on development costs which may then be spent on creating new media files, but also avoid learners becoming bored with plain text learning content.

In creating highly interactive LOs, multimedia elements can often be adopted as learning resources. The cost-effective model suggests converting these multimedia files into bandwidth-friendly file formats, as listed in Table 3.2. Using bandwidth-friendly file formats can reduce large media files into smaller sizes and hence accelerate content delivery over different bandwidths. In addition, adopting these common file formats can ensure the presentation of learning content: Learners do not need to pay extra for file decoders to view the learning content.

In contrast to traditional learning content, the design of a LO should also involve designing metadata to describe related LOs. In the cost-effective model, high quality metadata can be easily added into LOs by using authoring tools. As a self-described component of LOs, metadata provides key information to help make LOs sharable and reusable.

After determining the structure of LOs, an interactive learning environment should be designed for releasing the learning content and supporting learners' learning. Currently, LMS provides a collection of tools to help instructional designers to build a Virtual Learning Environment (VLE). The common elements which should be designed and implemented in the VLE include the syllabus for the course, student registration, access rights, learning activities, communication support, and assessments [62].

The cost-effective content development model believes that an interactive learning environment can enhance learning experiences and facilitate learning outcomes, and thus suggests implementing three interactive modes: Interaction between learner and content, interaction between learners, and interaction between instructor and learners. However, to make the development plan executable, instructional designers should become familiar with adopting LMS before the design process.

To ensure the quality of the created learning content, quality inspection policies should be established. These policies should provide evaluation criteria for checking the quality of the created LOs and the learning environment, and will be used as quality checking guidelines in the subsequent processes. According to the principles of quality inspection in Table 3.5, the outcomes of the proposed cost-effective model satisfy the medium level quality checking policy.

The last task of the design flow chart is to design how to assess learning outcomes and evaluate the quality of the LOs. In the cost-effective model, the evaluation is designed and implemented based on the systematic assessment functions provided by the LMS. In fact, the inherent capability of LMS supports tracking and reporting of learners' actions, learning progress and test results. LMS automatically processes the collected data and produces relevant statistics to instructors as required. In addition, flexible tools in LMS can help instructors to create assessments that evaluate learning outcomes; thus, LMS is a cost-effective method to perform the evaluation in the proposed model.

5.3.2 Learning Content Development

During the content development phase, the main task is to implement the detailed design documents. According to the structure of the distributed learning model, content authors can execute the detailed design documents on their own computers and upload the created LOs to the LOR later.

Before producing LOs, related learning materials should be selected and classified into different folders on the computer. The cost-effective content development model requires copyright inspection to avoid legal problems when content authors adopt authorized learning resources to improve the quality of the learning content. After preparing all learning resources, content authors can start creating LOs by using open

source authoring tools. During the LO production, content authors may need to create some new media files to add interaction between the learner and the content. Flash could be a good option to increase the interactivity level of LOs [3]. Figure 5.8 illustrates the learning content development process of the proposed cost-effective content development model.

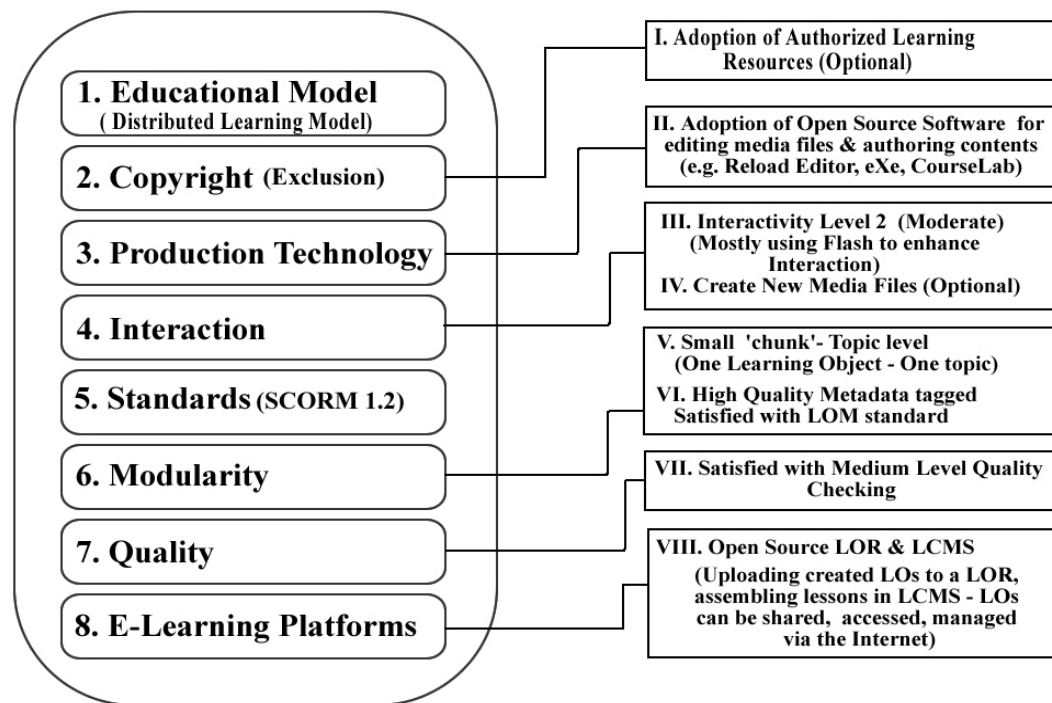


Figure 5.8: Learning Content Development Process of the Cost-effective Content Development Model

After forming the structure of the LO and related resources, metadata should be tagged to provide additional information about the LO. High quality metadata can enhance reusability of the learning content and enable LO communication with the LMS. As the designed LOs comply with SCORM 1.2 standards in the proposed cost-effective model, created LOs should be encapsulated and exported as SCORM 1.2 content packages. Previewing and quality checking for these content packages are needed before upload to the LOR.

At the end of the content development process, an e-Learning platform should be established to store LOs and prepare for content publication. After content authors upload created LOs to the LOR, instructors can start to retrieve relevant LOs from the

repository based on the syllabus. Retrieved LOs are organized into learning sequences and assembled as lessons in the LCMS. These content aggregation packages are then ready to be published in the e-Learning course.

5.3.3 Learning Content Publication and Evaluation

In the last stage of content development, the e-Learning course will be released and delivered to target learners. Learning content that has been organized into e-Learning lessons can be exported as SCORM 1.2 content aggregation packages from LCMS. To publish the e-Learning course, instructors must create a course on LMS, import related content aggregation packages into the course, and set the release date. The learning content publication process of the cost-effective content development model is illustrated in Figure 5.9.

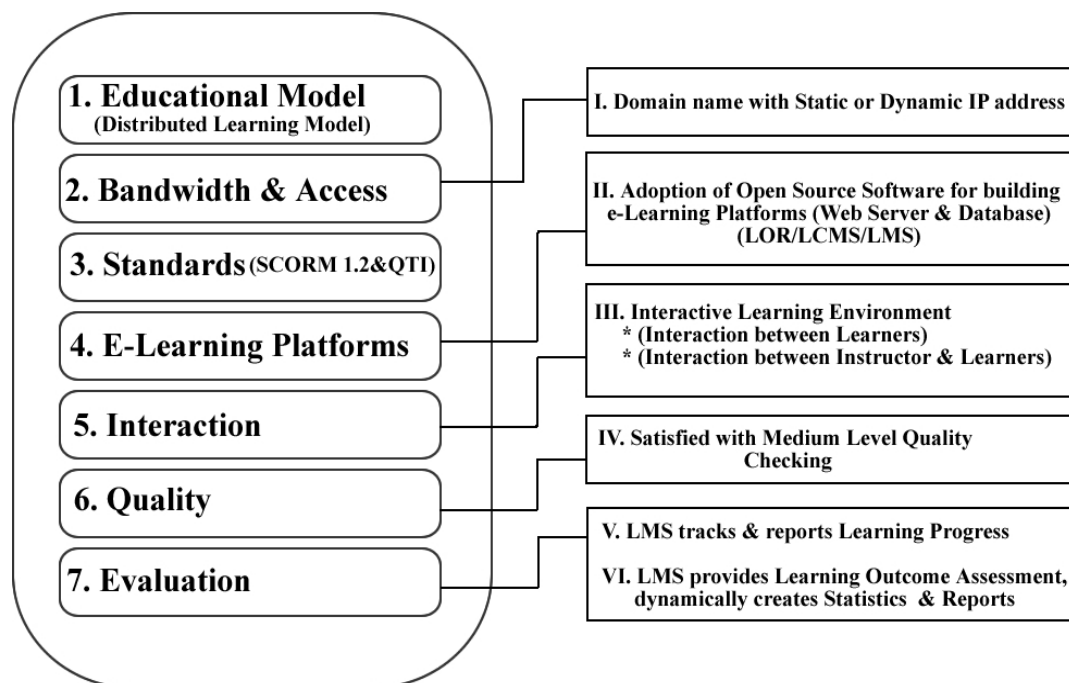


Figure 5.9: Learning Content Publication and Evaluation Process of the Cost-effective Content Development Model

After publishing the learning content, the proposed cost-effective model suggests that the instructor should establish an interactive learning environment in this virtual classroom to facilitate learners' active participation. Learning activities such as critical thinking tasks and tutorials can help learners to review their acquired knowledge, whilst

forums and frequently asked questions enable discussion between participants in the course, and assignments and online quizzes can evaluate learners' learning outcomes during the learning process or at the end of learning sections. Moreover, assessments could be reused as LOs if the created assessment questions comply with IMS QTI 2.1 specifications.

Before publishing learning content, instructors still need to go through the entire learning process to ensure the quality of the created course. If an online course is released with problems, poor learning experiences will result and thus affect learners' engagement in the course. Evaluation is implemented as soon as the course is released, where instructor can track the learning progress of each learner in LMS. By analysing reports where provided by LMS, instructors can give feedback to each learner and improve learning activities in the course. At the end of the session, students' feedback and system statistics can help the content author to address problems in the LOs and thus enhance the LO quality.

5.4 Conclusion

To summarise, this chapter proposed a cost-effective content development model for the design, development and publishing of learning content. This cost-effective model is constructed by assigning suitable development strategies to identified variables. In addition, OSS is widely adopted in the proposed cost-effective model to minimize the development cost. By following elaborate development strategies in the proposed cost-effective content development model, SCORM-conformant RLOs can be created and delivered to target learners at a minimum cost. In the next chapter, an experimental platform consisting of OSS is designed and implemented to provide more detailed information about the proposed cost-effective model.

CHAPTER 6. TESTING THE PROPOSED COST-EFFECTIVE MODEL ON AN EXPERIMENTAL PLATFORM

This chapter presents a reconfigurable, experimental software platform specifically designed and implemented to verify the theoretical proposed cost-effective content development model. The proposed platform provides a unified system for producing and publishing Learning Objects (LOs). Authoring tools and e-Learning platforms within the platform adhere to the SCORM 1.2 standard and allow the creation of SCORM-conformant LOs that are exportable and executable on different SCORM compliant e-Learning systems.

Based on this experimental platform, a case study has been conducted through converting pre-existing course materials into LOs and creating an e-Learning course for distribution. The objective of this case study is to provide more detailed information about the proposed model in a practical approach. Moreover, because the outcomes of the proposed cost-effective model are described as flexible, sharable and reusable LOs, the standards compliance of experimental platform has been evaluated, and the evaluation results indicate that the proposed platform can be used as an exemplar to support the usefulness of the cost-effective content development model.

6.1 The Introduction of Experimental Platform

The cost-effective content development model highlights that adopting Open Source Software (OSS) for producing and publishing learning content can result in significant cost savings. To comply with this strategy, an experimental platform which mainly consists of different OSS packages has been built. Figure 6.1 depicts the components of the experimental platform.

As the operating system on the client side is hard to pre-determine and thus exclude from the cost-effective model, this experimental platform has been built and replicated on two operating systems: UNIX and Microsoft Windows. For setting up the e-Learning platforms, an Apache web server with an interpreter of the scripting language PHP [63] and a relational MySQL database was installed on these two operating systems. A web server running on UNIX with a static IP address is provided by the Faculty of Informatics at the University of Wollongong. Another web server which runs on

Microsoft Windows is connected to the Internet through an ADSL broadband connection with a dynamic IP address.

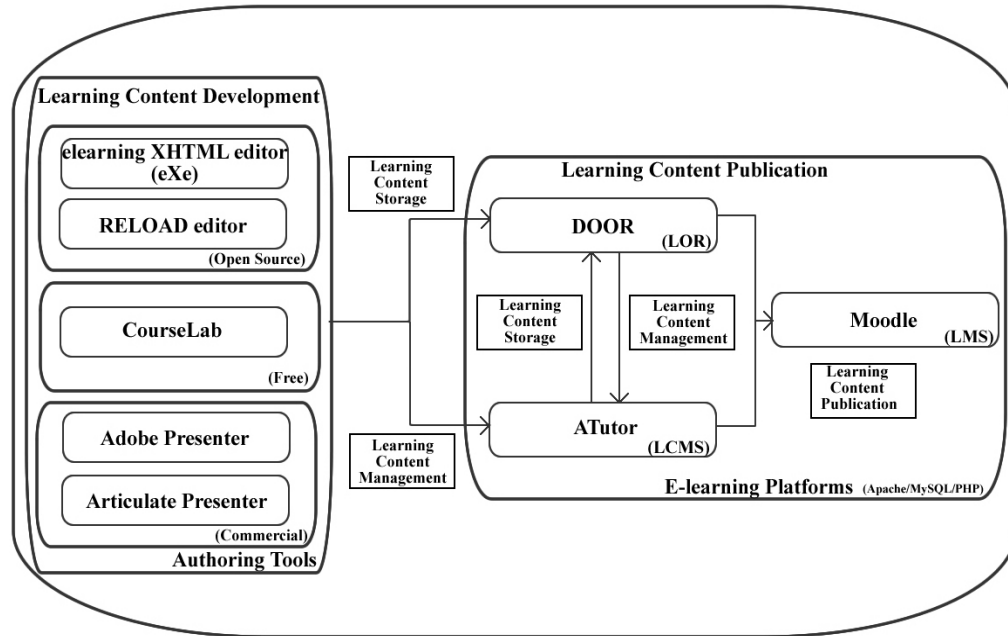


Figure 6.1: The Components of Experimental Platform

After building the web server, Moodle, DOOR and ATutor are deployed as LMS, LOR and LCMS, respectively, to build a complete experimental e-Learning platform for managing, storing and publishing learning content. These OSS packages not only include main features that can be found in proprietary software, but also offer innovative functionality that facilitates the learning outcomes. In addition, these software distributors also provide multiple versions for different operating systems, hereby enhancing the flexibility of the proposed model.

In addition to the e-Learning platform, RELOAD Editor, CourseLab, and eXe are selected as authoring tools for creating and packaging the learning content. These open source solutions provide a cost-effective way for learning content development, hence they can be considered as viable alternatives to commercial software packages.

Furthermore, considering that instructors may use their own commercial tools to create learning content, LOs that are compiled by Articulate Presenter [64] and Adobe Presenter [65] are used for evaluating the standards compliance of the experimental

platform. Both Articulate Presenter and Adobe Presenter are commercial authoring tools and offer 30-day trial versions of fully-functional packages to prospective customers. The main features of these two software packages are as follows:

- Articulate Presenter is a commercial authoring tool that can quickly create Flash-based presentations and e-Learning courses from PowerPoint. With Articulate Presenter, the content author can save learning content in the universally accepted Flash format such that created learning content can run on any web server or LMS. Learning content can also be exported as SCORM and AICC compliant content, thus the instructor can easily track learning results on LMS [64].
- Adobe Presenter is a commercial authoring tool that enables anyone to transform presentations into engaging Flash experiences. By using Adobe Presenter, narration, animations, interactivity, quizzes, and software simulations can be easily added to e-Learning courses. Moreover, learning content created with Adobe Presenter can be saved as AICC and SCORM compliant content packages [65].

6.2 A Case Study: Converting Existing Course Materials into Learning Objects

This section describes a case study that uses the proposed cost-effective content development model to create and deploy cost-effective learning content. In this case study, an existing traditional course is transformed into an e-Learning course that integrates LOs as a significant component of the course structure. Rather than create new learning content, existing course materials are used as a basis for creating LOs that are eventually combined together to create an e-Learning course.

‘Web Technology and Applications’ is a six-credit point, thirteen-week course for postgraduate students at the University of Wollongong. This subject is taught through traditionally delivered lectures and tutorials, and is oriented towards gaining familiarity with current Internet technologies and applications. Moreover, the instructor also creates an online classroom supported by WebCT Vista [34] to release lecture notes and provide more practice tasks to facilitate learning. Lecture notes are released as PDF files, as this file format has indicated that efforts are required to modify and update the learning content within it. It is also difficult to share these lecture notes among other instructors or reuse the notes for other educational purposes.

The aim of this study is to solve addressed issues by converting existing course materials into separate LOs and transferring the entire course to the experimental platform. The following discussion gives a staged overview of the learning content development in this case study.

6.2.1 Learning Content Planning and Design

As the development strategies have already been given to most of the variables in the proposed cost-effective content development model, the work of the design stage simply concentrates on the structure of the course and the LOs. The design process can be divided into the following three steps.

Step 1: Design the Structure of the e-Learning Course

Based on the clearly defined educational objectives of the traditional course, the structure of the e-Learning course is firstly designed along with the topics of each lesson, learning practice tasks and activities, and assessments. Figure 6.2 illustrates the designed structure of the online course.

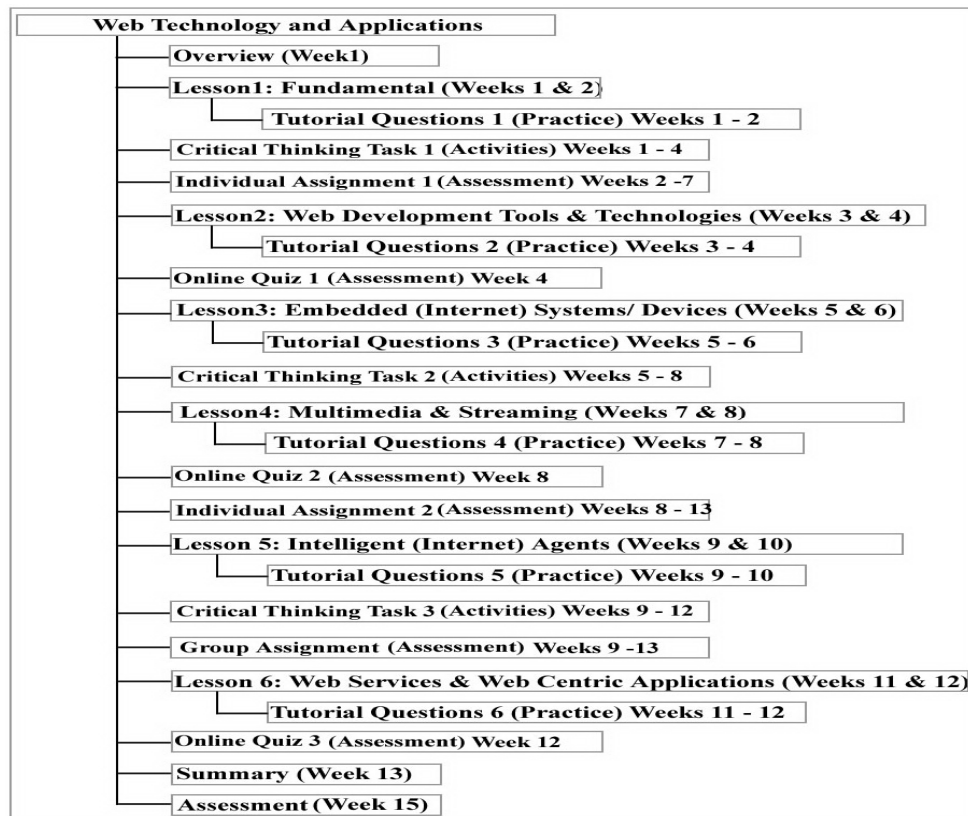


Figure 6.2: The Structure of the Online Course

Step 2: Determine Clear Learning Objectives for Each Learning Object

The proposed cost-effective content development model outlines narrowing the granularity of each LO into topic levels which can enhance the reusability of the LOs. With this in mind, learning units within each lesson are analysed in order to clearly determine specific learning objectives for each learning object. Each learning objective is documented and used as a basis for LOs design. Table 6.1 gives an example of determining the learning objectives in Part A of Lesson 1.

Learning Units	Topic Name	Topic Type
Big Picture	1. The Big Picture	Overview
Hardware & Software (Part A)	1. Hardware Introduction	Overview
	2. Hardware Classification	Concept
	3. Components of a Computer	Concept
	4. The Central Processing Unit	Concept
	5. Memory	Concept
	6. Speed and Power	Concept
	7. Input Devices	Concept
	8. Output Devices	Concept
	9. Storage Devices	Concept
	10. PC Hardware	Concept
	11. Software Introduction	Overview
	12. Software Classifications	Concept
	13. Acquiring Software	Concept
	14. Operating System	Concept
	15. Unix/Linux	Concept
	16. Five Generations of Programming Languages	Concept

Table 6.1: Determining Clear Learning Objectives in Part A of Lesson 1

Step 3: Split All Existing Content into Discrete Learning Objects

According to the definitions of a RLO, a RLO can be considered as self-contained, chunks of learning content [11]. Step 3 of the learning content design process followed this definition, and all existing course content based on the identified learning objectives of Step 2 are broken down and split into individual topic-specific folders on the computer. Learning materials within these prepared folders will be converted into discrete LOs in the learning content development process. An example of splitting existing course content into individual topic-specific folders is shown in Figure 6.3.

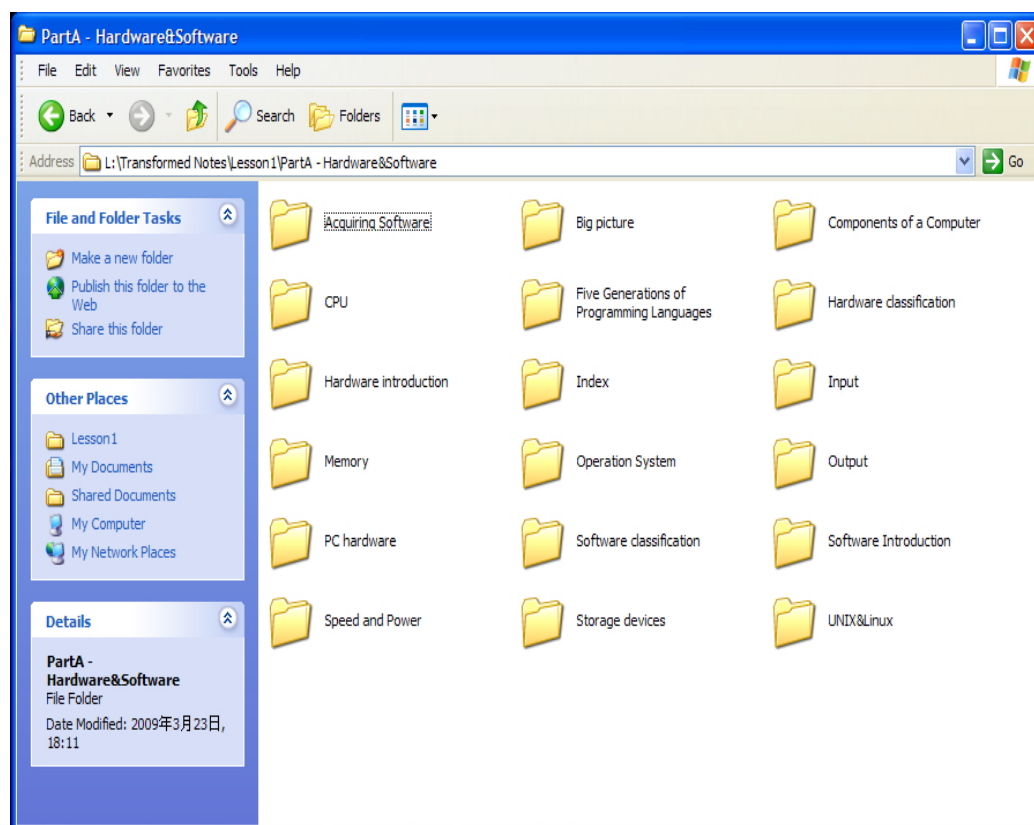


Figure 6.3: Splitting Existing Course Content into Individual Topic-specific Folders

6.2.2 Learning Content Development

Once learning materials for each topic are prepared, these files are then converted into LOs by using authoring tools. Reload Editor, CourseLab and eXe are chosen in the experimental platform to convert different types of learning materials. These authoring tools offer different versions for different types of operating systems, and standards conformance also allows these tools to interact with each other.

In order to ensure that the created LOs are easily accessible, sharable and reusable across different e-Learning platforms, the cost-effective content development model suggests that the development of each LO should comply with SCORM 1.2 standards. The learning content development process can be divided into four steps.

Step 1: The Development of Learning Objects

As a LO is web-based learning content, learning materials should be converted into web-accessible learning content such as HTML or XHTML files before compression into SCORM 1.2 content packages. Learning materials from an existing course are in three basic file formats: Web pages, plain text and Microsoft Office PowerPoint. Selected authoring tools in the experimental platform provide efficient functions to handle these learning materials.

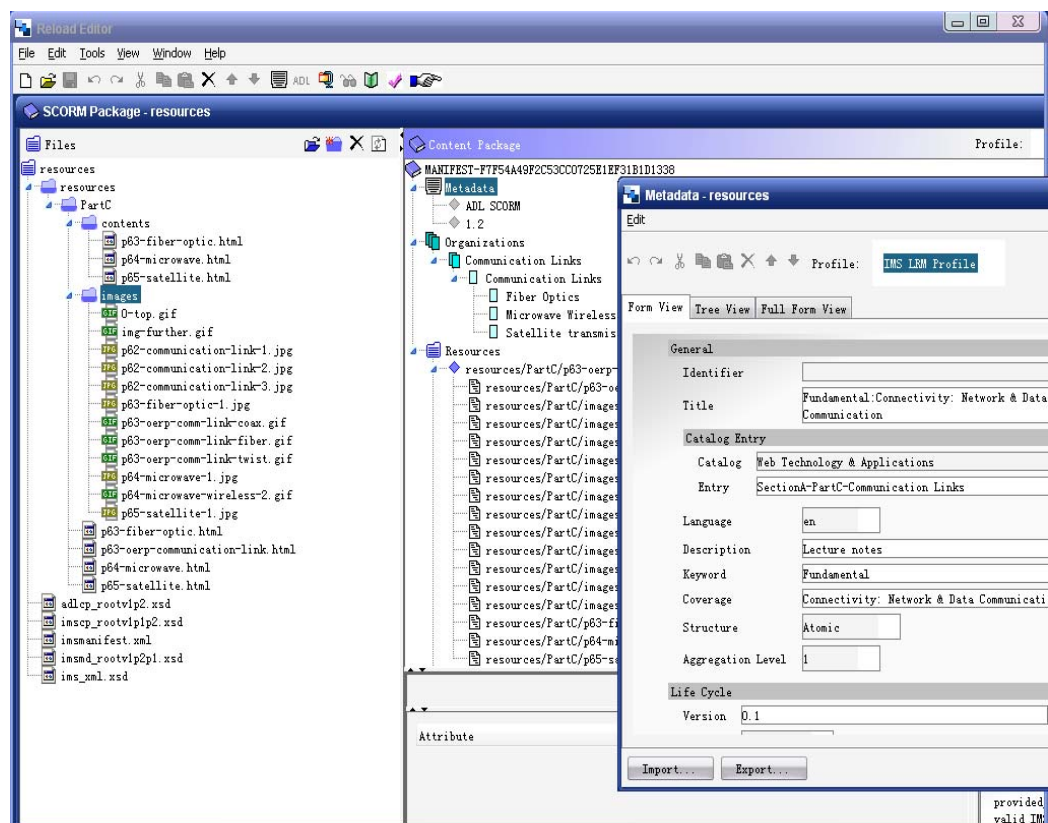


Figure 6.4: Converting Existing Web-based Learning Materials into LOs Using Reload Editor

Reload Editor is used to package web-based learning materials into SCORM-compliant LOs. Existing web-based learning materials and resources are imported into Reload

Editor, and organized into designed structures, with relevant metadata added. Before exporting a LO as a SCORM 1.2 content package, the created LO is previewed in the editor to ensure correct presentation of content components [51]. Figure 6.4 depicts converting web-based learning materials into a LO using Reload Editor.

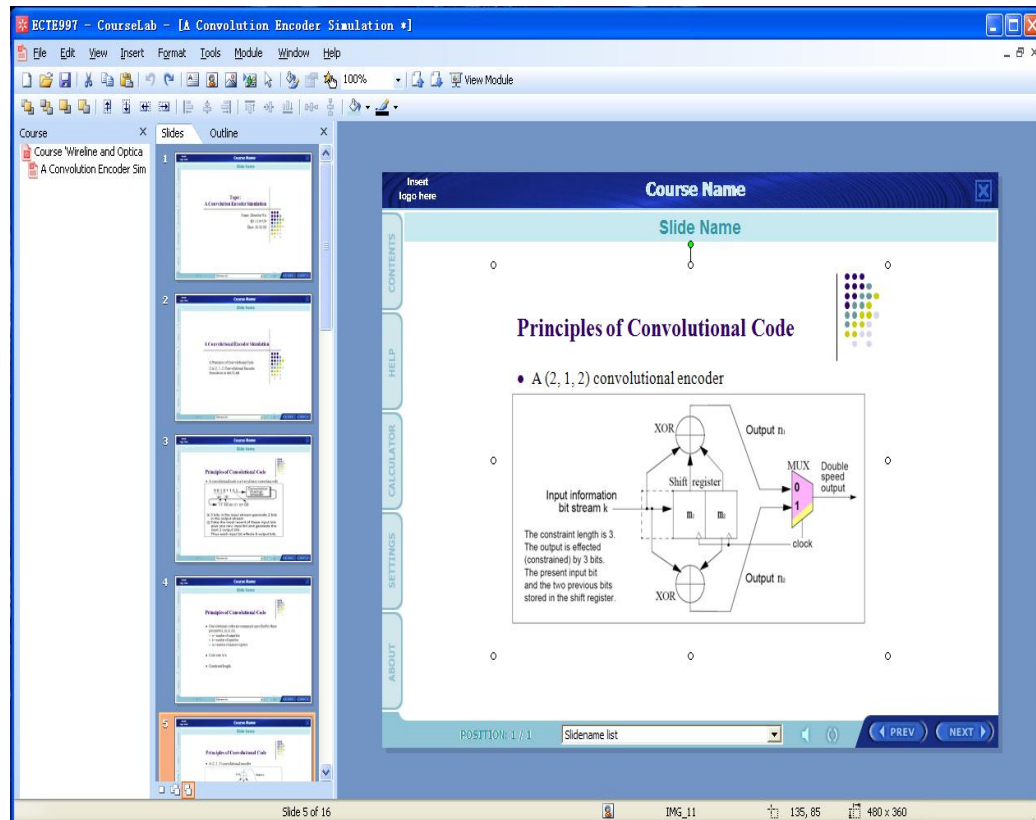


Figure 6.5: Learning Content Development in CourseLab

CourseLab is used to transform PowerPoint presentation learning materials into LOs. Different from eXe and RELOAD Editor, CourseLab provides a familiar PowerPoint-like authoring environment to content authors. Through this friendly editing environment, content authors can easily add multimedia learning resources such as pictures, video clips and audio files, Flash movies, Shockwave applications, and Java applets into LOs [52]. In addition, CourseLab offers embedded tools to help instructors to organize learning materials into a hierarchy of slides. Figure 6.6 gives a screenshot of learning content development in CourseLab.

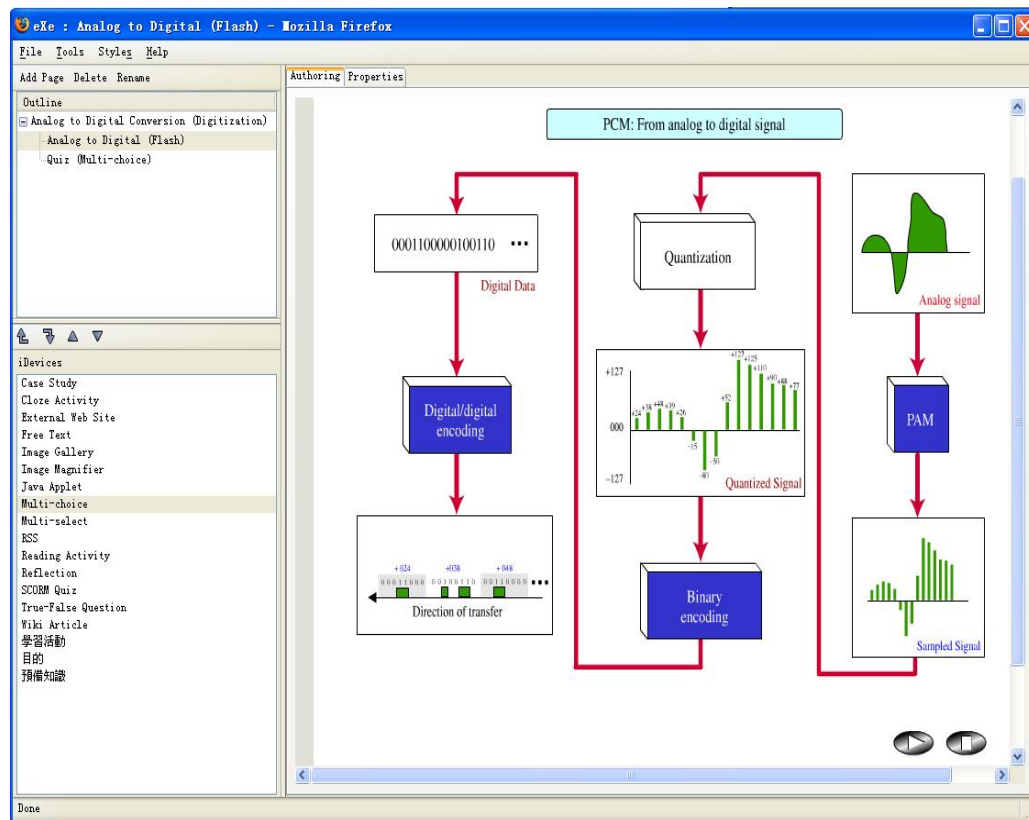


Figure 6.6: Inserting Embedded Media to the LO of Topic 'Analog to Digital Conversion'

eXe is used to create new web-based LOs or convert existing text files into XHTML files. This authoring tool is designed to help instructors to structure educational resources and package them into standard formats. Through the user-friendly GUI of eXe, learning practices and assessments are created and embedded into the LO. In addition, media files are also added to the learning content to improve the interactivity level of the LOs [53]. Figure 6.5 illustrates inserting embedded media into the LO of topic 'Analog to Digital Conversion'. By using eXe, interactive learning content can be produced easily and efficiently.

Step 2: The Quality Inspection of Created Learning Objects

The quality inspection is implemented after all existing learning materials have been converted into relevant LOs. Created LOs are imported to the LCMS for the review of learning objectives and checking of accessibility. The ‘Accessibility’ function of ATutor is used for checking potential access problems of LOs (see Figure 6.7); this function depends on an AChecker experimental web service developed at the Adaptive Technology Resource Center (ATRC) [55]. LOs that do not pass the quality inspection are modified or recreated.

Edit Content

Guideline Status: **FAIL WCAG 2.0 L2**

Unsaved changes have been made. [Save] [Close] [Close after saving]

WCAG 2.0 L2 Problems

Group	Known	Potential
1.1 Provide text alternatives for all non-text content	1	4
1.3 Ensure that information and structure can be separated from presentation	0	11
1.4 Make it easy to distinguish foreground information from its background	0	3
2.4 Provide mechanisms to help users find content, orient themselves within it, and navigate through it	0	6
3.1 Make text content readable and understandable	0	1
3.2 Make the placement and functionality of content predictable	0	2

Known Problems

You must modify your page to resolve these known problems.

img:

Known Problem: (line 31) img element missing alt attribute.
 Repair: Add an alt attribute to your img element.

 Content processing error: 6276

Potential Problems

Review the potential problems below and select the appropriate radio buttons for each problem. After reviewing all the potential problems, select the 'Make Decisions' button below

TITLE:

Potential Problem: (line 2) title might not describe the document.

☒ title describes the document. ☐ title does not describe the document. ☐ No decision

Figure 6.7: Using the Accessibility Functions of ATutor to Check Potential Access Problems of LOs

Step 3: The Storage and Management of Created Learning Objects

According to the proposed cost-effective model, the selected LOR should support SCORM 1.2 content packages. But to date, no open source or free LOR that fully complies with SCORM 1.2 has been found. Thus, an open source LOR called DOOR that supports IMS Metadata 1.2.1 and Content Package 1.1.3 specifications is adopted in the experimental platform for learning content storage. In fact, Content Package 1.1.3 specifications are embodied as important parts in SCORM 1.2.

DOOR is a central database that is used for storing digital learning content. By using DOOR, digital learning content can be stored locally and accessed remotely through the Internet. To facilitate the reusability and management of LOs, created LOs are uploaded and saved in DOOR. These LOs can be easily located and retrieved through searching functionality provided by DOOR [54]. Figure 6.8 illustrates retrieving a LO in DOOR.

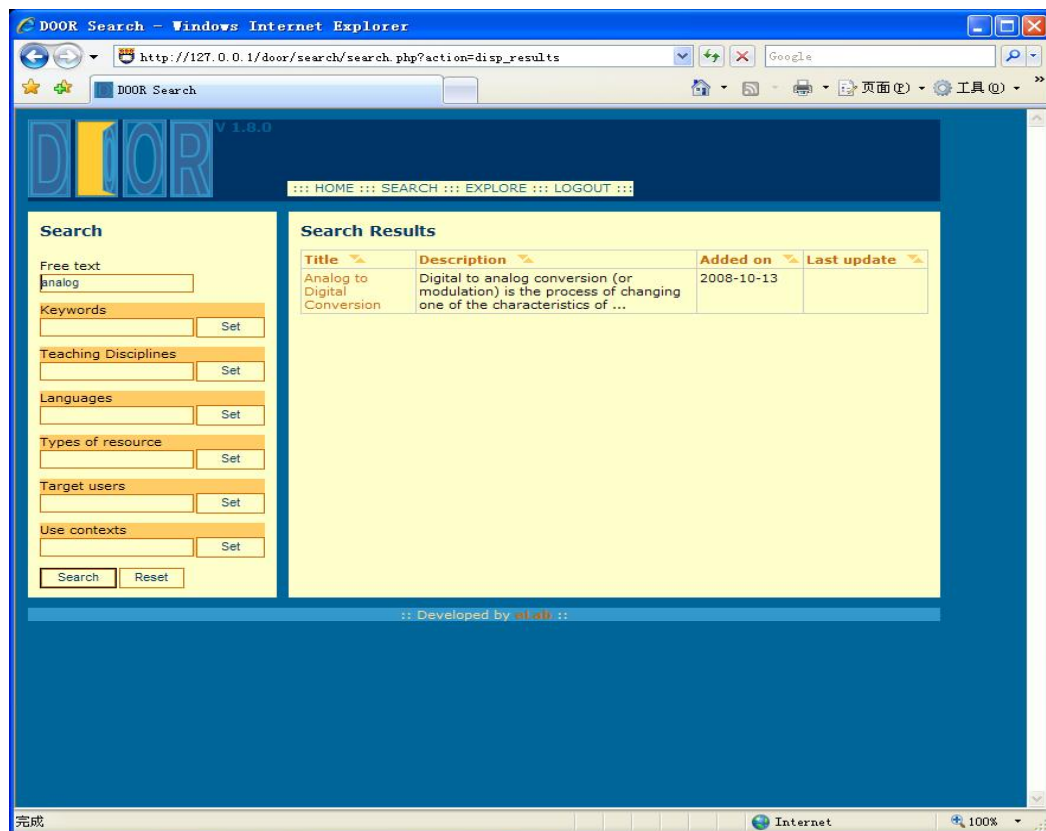


Figure 6.8: Retrieving a LO in DOOR

Step 4: The Construction of Course Content

As shown in Figure 6.2, the e-Learning course consists of six lessons. For constructing this e-Learning course, each lesson is formed by aggregating LOs of related topics. Based on the syllabus, relevant LOs are retrieved from DOOR and imported into ATutor. In ATutor, a tool called ‘Content Properties’ is used to organize LOs into learning sequences (see Figure 6.9). Organized course content is then exported as aggregated content packages ready for publication.

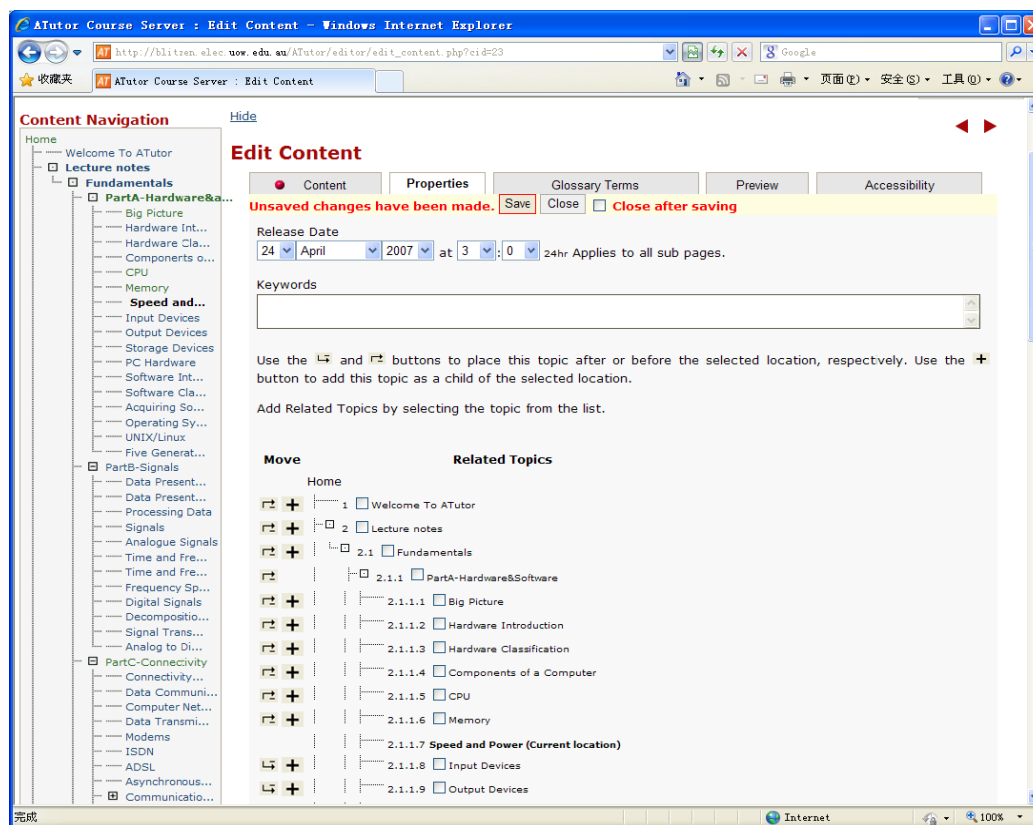


Figure 6.9: Organizing LOs into Learning Sequences in ATutor

6.2.3 Learning Content Publication and Evaluation

Once all LOs have been created and combined into higher-level learning units, the entire course can be constructed and released to the learners. Along with course content publication, learning activities, practice tasks and assessments are also created to build an interactive learning environment that provides the best experience to facilitate student learning of the content. Content publication and evaluation can be divided into four steps in this stage.

Step 1: Course Construction

The purpose of creating these RLOs is to allow instructional designers to construct online courses by simply choosing and combining available materials, whilst enabling the reuse of these topic-level LOs in different courses with common elements in the content. For publishing the learning content, an online course is created in Moodle, where aggregated content packages, practice tasks, activities, and assessments are added to the course by following the timetable decided upon in the course structure. Figure 6.10 gives a screenshot of an online course created in Moodle.

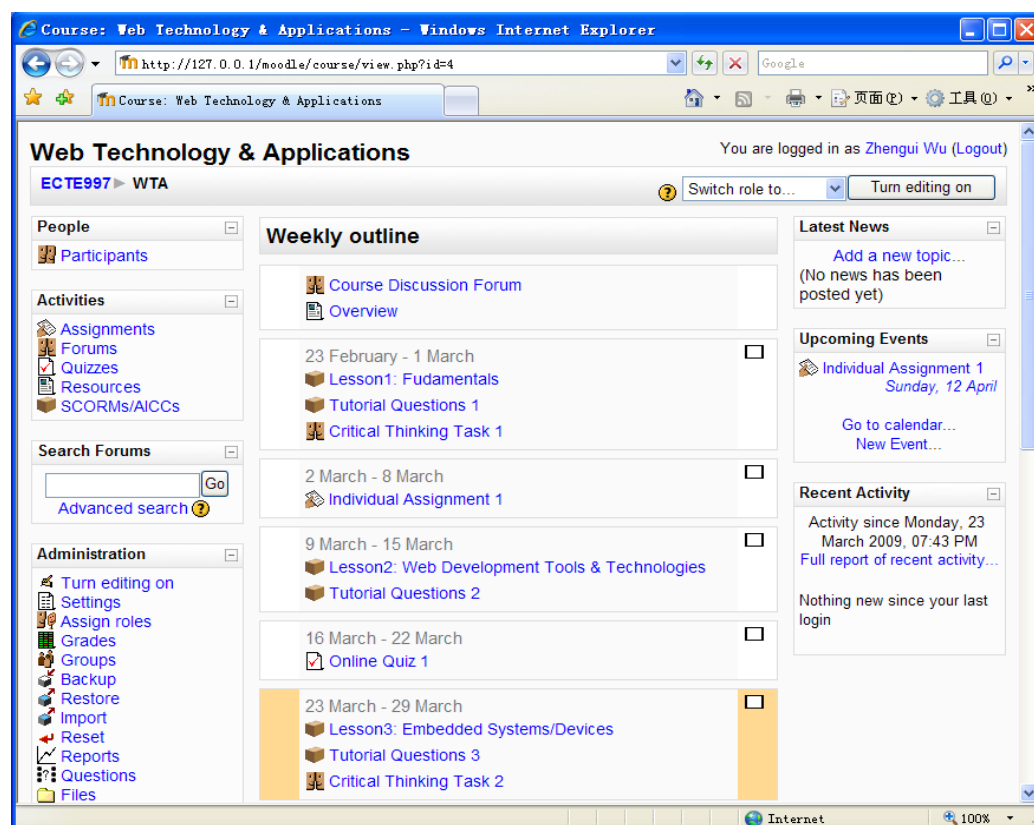


Figure 6.10: A Screenshot of an Online Course Created in Moodle

Step 2: Quality Inspection of the Created Course

Before releasing the course to learners, all the learning content in the online course is previewed and double checked to ensure the quality of the created course. Moreover, practice tasks and assessments within the course are also previewed to avoid interrupting the learner during the learning process. Figure 6.11 shows the preview of Online Quiz 1.

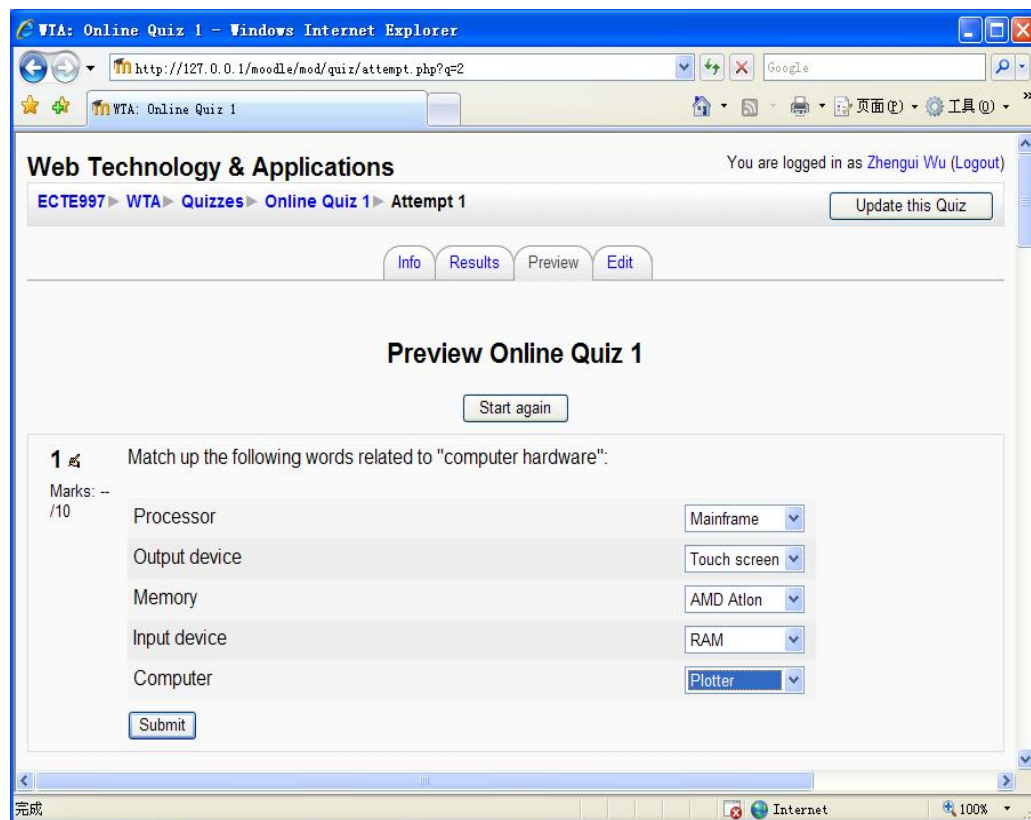


Figure 6.11: The Preview of Online Quiz 1

Step 3: Course Publication

After the quality inspection, the online course is released and published to learners. As soon as the course is released, learners are able to access the learning content and participate in learning activities by using their own web browser via the Internet. Figure 6.12 gives a screenshot of the released learning content from the online course.

The screenshot shows a web browser window with the title "ECTE997: Lecture Notes Week 1&2 - Windows Internet Explorer". The address bar shows a URL starting with "http://127.0.0.1/moodle/mod/resource/view.php?r=1&frameset=ins&page=32". The page content is organized into a sidebar and a main area.

Sidebar Navigation:

- Fundamentals
 - PartA-Hardware&Software
 - Big Picture
 - Hardware Introduction
 - Hardware Classification
 - Components of a Computer
 - CPU
 - Memory
 - Speed and Power
 - Input Devices
 - Output Devices
 - Storage Devices
 - PC Hardware
 - Software Introduction
 - Software Classifications
 - Acquiring Software
 - Operating Systems
 - UNIX/Linux
 - Five Generations of Programming Languages
- PartB-Signals
 - Data Presentation & Processing
 - Introduction
 - Data Presentation
 - Processing Data
 - Signals
 - Analogue Signals
 - Time and Frequency Domains
 - Time and Frequency Domains 1
 - Frequency Spectrum and Bandwidth
 - Digital Signals
 - Decomposition of Digital Signals
 - Signal Transformations
 - Analog to Digital Conversion**
- PartC-Connectivity
 - Connectivity Introduction
 - Data Communication

Main Content Area: Analog to Digital Conversion (Digitization)

We often need to digitize an analog signal. For instance, to send human voice over a long distance, we need to digitize it since digital signals are less prone to noise. This process is called analog to digital conversion or digitizing an analog signal.

Diagram: A graph of an analog signal (a sine wave) is shown on the left. An arrow points to a yellow box labeled "Analog/digital encoding (codec)". Another arrow points to a graph of a digital signal (a square wave) on the right.

Tips or Warning:

The key technical concept of the Web is digitization: the act of converting communication content such as an image, an audio clip, a video, an essay etc. into a series of numbers. Digitization enables the Internet, and opens up the doors to the future of communication.

NOTES: Digital to Analog Conversion

Digital signals can be converted to analog signals. Digital to analog conversion (or modulation) is the process of changing one of the characteristics of an analog signal based on the information in a digital signal (0s and 1s).

Diagram: A graph of a digital signal (a square wave) is shown on the left. An arrow points to a box labeled "PAM". Another arrow points to a graph of a modulated signal (a square wave with varying amplitudes). A final arrow points to a box labeled "Quantization".

Figure 6.12: A Screenshot of the Released Learning Content from the Online Course

Step 4: Learning Content Evaluation

Once the online course is released to students, Moodle starts to track each student's learning progress including the usage of learning content and the participation in each activity. The results of each learning outcome assessment are also recorded in Moodle. Moodle offers multiple exporting functions to enable instructor cross-searching, browsing, and downloading of reports and statistics by choosing different parameters such as courses, groups, students, dates, activities and actions. An example of the logs from Critical Thinking Task 1 in Moodle is shown in Figure 6.13.

Time	IP Address	Full name	Action	Information
Mon 23 March 2009, 07:43 PM	203.219.216.3	steven Dell	forum view discussion	A view about computer technology development
Mon 23 March 2009, 07:43 PM	203.219.216.3	steven Dell	forum add post	Re: A view about computer technology development
Mon 23 March 2009, 07:42 PM	203.219.216.3	steven Dell	forum view discussion	A view about computer technology development
Mon 23 March 2009, 07:42 PM	203.219.216.3	steven Dell	forum view forum	Critical Thinking Task 1
Mon 23 March 2009, 07:42 PM	203.219.216.3	Eva Lin	forum view discussion	A view about computer technology development
Mon 23 March 2009, 07:42 PM	203.219.216.3	Eva Lin	forum add post	Re: A view about computer technology development
Mon 23 March 2009, 07:41 PM	203.219.216.3	Eva Lin	forum view discussion	A view about computer technology development
Mon 23 March 2009, 07:41 PM	203.219.216.3	Eva Lin	forum view forum	Critical Thinking Task 1
Mon 23 March 2009, 07:41 PM	203.219.216.3	Tim Duncun	forum view forum	Critical Thinking Task 1
Mon 23 March 2009, 07:40 PM	203.219.216.3	Tim Duncun	forum add discussion	A view about computer technology development
Mon 23 March 2009, 07:39 PM	203.219.216.3	Tim Duncun	forum view forum	Critical Thinking Task 1
Mon 23 March 2009, 07:36 PM	203.219.216.3	Zhengui Wu	forum view forum	Critical Thinking Task 1
Mon 23 March 2009, 07:35 PM	203.219.216.3	Zhengui Wu	forum view forum	Critical Thinking Task 1
Mon 9 February 2009, 04:30 PM	127.0.0.1	Zhengui Wu	forum add	Critical Thinking Task 1

Figure 6.13: The Logs of Critical Thinking Task 1 in Moodle

Through analysing the relevant statistics, the created LOs are evaluated and problems within these LOs are fixed. Moreover, learning practices, activities and assessments in the course are also updated to provide better learning experiences for future learners.

6.3 The Standards Compliance of the Experimental Platform

According to the proposed cost-effective content development model, created learning content should comply with SCORM 1.2 standards that enable these LOs to be sharable and reusable on SCORM-conformant e-Learning platforms. The case study also indicates that unnecessary costs and efforts can be avoided when developing LOs on a unified experimental platform.

However, authoring tools that are used for creating LOs in the case study only represent a small part of the available SCORM-conformant tools. Considering that the instructor may reuse LOs which are created by other tools such as commercial authoring packages, the standards compliance of the experimental platform should be evaluated to determine the performance of these sharable LOs on the platform.

Furthermore, due to dissimilar understandings of the standards, OSS distributors may create e-Learning tools using different structures; these differences may lead to compatibility problems when sharing LOs between different e-Learning platforms. Therefore, the results of the evaluation can be used as a guide to help users to select most appropriate software packages in the cost-effective content development model.

For evaluating the standards compliance of the experimental platform, LOs that are created by Reload Editor, CourseLab, eXe, Articulate Presenter and Adobe Presenter are used as example learning content to assess the compatibility of the selected e-Learning platforms.

To evaluate the selected LOR, all example LOs are uploaded to DOOR via the Internet, and then the search function is used to locate and preview each LO. Finally, LOs are retrieved and downloaded to the local disk. Table 6.2 shows the evaluation results of SCORM-conformance in DOOR. Because DOOR does not support the SCORM 1.2 standards, not all LOs can be previewed in DOOR. However, other efficient functions justify keeping DOOR in the experimental platform.

Authoring Tools (SCORM 1.2) DOOR (LOR)	eXe	Reload Editor	CourseLab	Articulate Presenter	Adobe Presenter
Import	✓	✓	✓	✓	✓
Search	✓	✓	✓	✓	✓
Preview	✗	✗	✗	✗	✗
Retrieve	✓	✓	✓	✓	✓

Table 6.2: The Evaluation Results of SCORM-conformance in DOOR.

In the case study, ATutor is not only used for aggregating LOs into larger learning units, but also for editing and updating LOs. Therefore, the assessment concentrates on the aggregation and management of example LOs in ATutor. LOs that are retrieved from the LOR are imported into ATutor, modifications are made, the LOs organized into learning sequences, and then exported as SCORM 1.2 aggregation content packages. The evaluation results are given in Table 6.3.

Authoring Tools (SCORM 1.2) ATutor (LCMS)	eXe	Reload Editor	CourseLab	Articulate Presenter	Adobe Presenter
Import	✓	✓	✓	✓	✓
Edit	✓	✓	✓	✗	✗
Preview	✓	✓	✓	✓	✓
Aggregate	✓	✓	✓	✗	✗
Export	✓	✓	✓	✓	✓

Table 6.3: The Evaluation Results of SCORM-conformance in ATutor

Due to Articulate Presenter and Adobe Presenter converting PowerPoint learning materials into Flash-based LOs with narration, ATutor provides a separate tool to support this kind of LO. Therefore, LOs created by Articulate Presenter and Adobe Presenter cannot be modified and combined with other LOs in ATutor.

The evaluation of SCORM-conformance in Moodle focuses on learning content publication. LOs that are produced by selected authoring tools and ATutor are imported into Moodle. Figure 6.14 and Figure 6.15 show the publication of created LOs by Articulate Presenter and Adobe Presenter in Moodle.

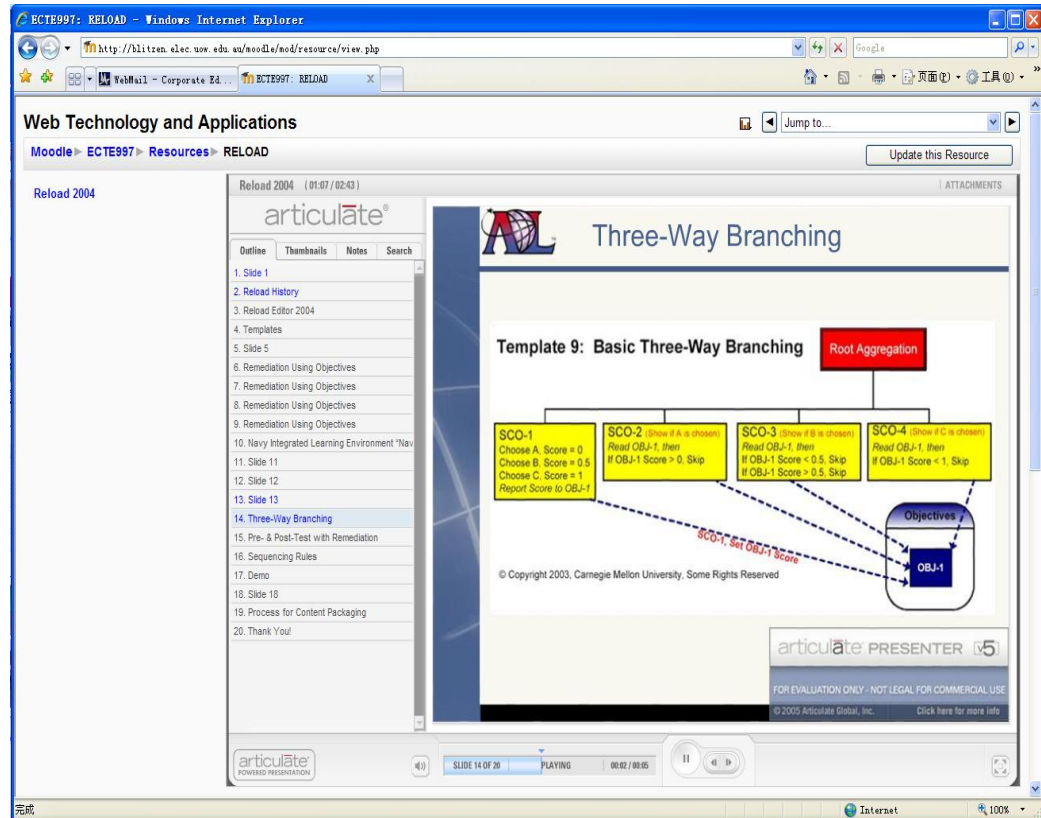


Figure 6.14: The Publication of Produced LOs by Articulate Presenter in Moodle

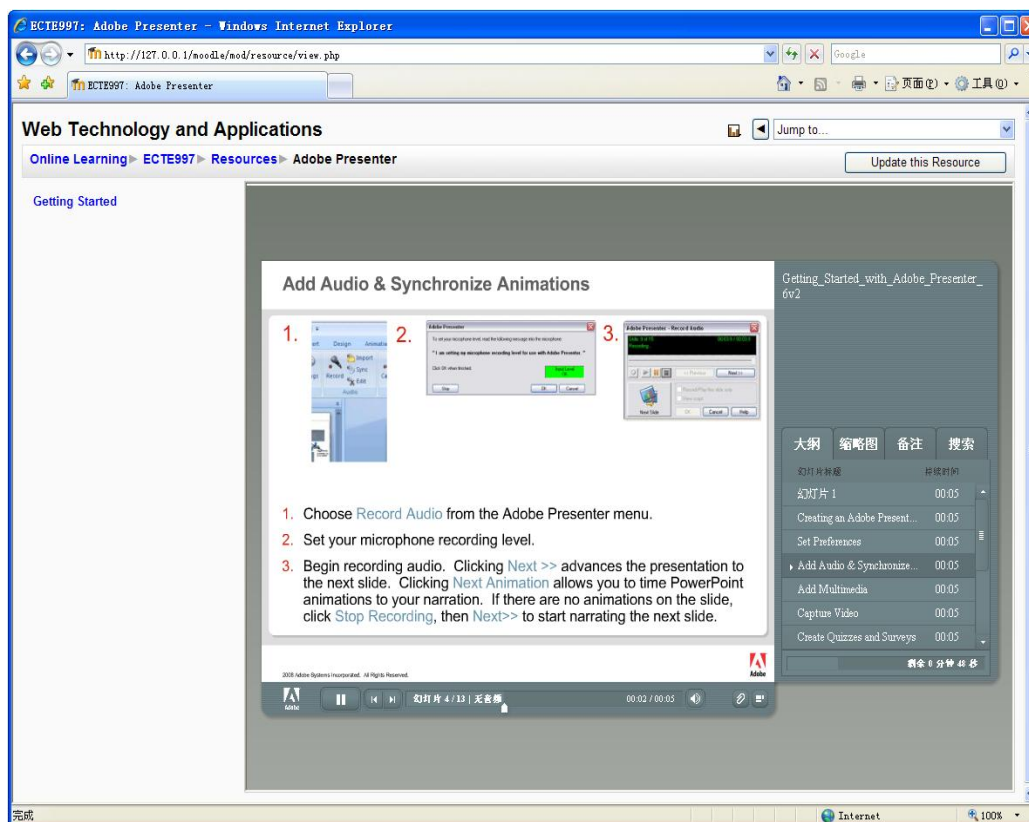


Figure 6.15: The Publication of Produced LOs by Adobe Presenter in Moodle

For learning content publication, Moodle indicates its good compatibility with SCORM-compliant LOs. LOs that are created in different authoring tools or exported from LCMS are easily published and delivered to target learners. The evaluation results of SCORM-conformance in Moodle are indicated in Table 6.4.

Authoring Tools & LCMS (SCORM 1.2)	eXe	Reload Editor	CourseLab	Articulate Presenter	Adobe Presenter	ATutor
Moodle (LMS)						
Import	✓	✓	✓	✓	✓	✓
Preview	✓	✓	✓	✓	✓	✓
Publish	✓	✓	✓	✓	✓	✓

Table 6.4: The Evaluation Results of SCORM-conformance in Moodle

6.4 Results

The experimental platform presented in this chapter highlights the key role of the LO in the design and development of learning content. Based on this experimental platform, a case study demonstrated that cost-effective learning content can be created by following the proposed cost-effective content development model, which assigns suitable development strategies to variables influencing the cost of learning content development.

The experimental platform mainly consists of OSS packages, where the proposed cost-effective content development model can take full advantage of these available applications. As the learning content development process has already been simplified in the cost-effective content development model, this platform can be considered as an example platform that has the potential to deliver learning content at a minimum cost whilst maintaining compliance with standards related to LOs.

CHAPTER 7. CONCLUSIONS AND FUTURE WORK

The growth of online courses at tertiary institutions has been closely followed by an equally significant increase in demands for digital learning content. Direct and indirect costs associated with design, development, publication and evaluation of learning content makes a relatively high percentage of the total cost of an e-Learning undertaking at universities. It is shown that as high as 60% of total e-Learning costs could be related to learning content. Increasing budgetary requirements of high quality learning content have bottlenecked the wide utilization of e-Learning for campus education and continuing education across the globe. Virtual educational institutions and universities are aware of the challenges, and research and development projects are attempting to find cost-effective approaches to tackle this issue.

This thesis proposed a comprehensive model that uses the concept and technology of Reusable Learning Objects (RLOs) and offers a minimized cost for the design, development and publication of learning content in a typical e-Learning program implemented in campus education. Steps towards building the proposed model and research efforts documented in this thesis consisted of two major parts; identification and prioritization of variables influencing the overall cost of learning content and the construction of a cost-effective content development model that utilizes the identified variables.

The proposed model makes use of two attributes associated with learning content used in e-Learning platforms. These are reusability feature of Learning Objects (LOs) and the modularity formation of the learning content; both have been effectively embedded into the proposed model. It is shown that these two features help the reduction of the overall cost of learning content to a level much lower than standard text-based contents in print or digital formats. More specifically, the model presented in this thesis is mostly suited for experimental science including engineering disciplines. This is because the distributed learning model used for the development of proposed learning content is directly relevant to technology and engineering programs.

7.1 Conclusions

In Chapter 2, a brief literature review was presented including the definitions of a Learning Object and its underlying technologies, the typical content development model,

and the classification of content development projects. It was shown that as a new concept of digital learning content, the Learning Object and its underlying technologies have been increasingly adopted in the development of e-Learning programs. To create the cost-effective learning content, the key role of the Learning Object in learning content development was highlighted.

In Chapter 3, ten essential factors that encompass pedagogy and technology related matters have been analysed. Based on common practice, the entire content development process associated with the deployment of Learning Objects and the underlying technologies was investigated and twelve variables that directly or indirectly influence the cost of learning content development were identified. These variables are:

- | | |
|--------------------------|----------------------------|
| 1. Required Resources | 2. Pedagogy |
| 3. Educational Model | 4. Bandwidth and Access |
| 5. Standards | 6. Production Technologies |
| 7. Modularity | 8. Interaction |
| 9. Copyright | 10. Quality |
| 11. E-Learning Platforms | 12. Evaluation |

The extent and significance of the listed variables in the context of 'cost' were investigated and documented, and potential solutions for minimizing the development cost were discussed.

In Chapter 4, the prioritization of variables was conducted and utilised in sorting the identified variables associated with the learning content development process. In line with the required model three processes, namely (1) planning and design, (2) development, and (3) publication and evaluation, were introduced and variables were distributed in the flowcharts of these processes based on common practices in the field. Two extreme content development scenarios: high and low cost structures were investigated. Through the analysis of different development strategies for each variable in these two structures, a feasible method for constructing a cost-effective content development model that covered the design, development and publication of learning content was deduced. Finally, identified variables were prioritized based on their significance and logical relationships in the learning content development process.

Chapter 5 described the construction of the target cost-effective model that utilized the controllable variables. To make the target model more practical, three identified variables and eight parameters were excluded from the model (See Table 1.1). Excluded variables and parameters either have less impact on the ‘cost’ or are not easy to minimize costs for. By directly drawing upon the rational and logical links between elements of the high and/or low cost structures, suitable development strategies were selected and assigned to given variables, which were then refined and prioritized in the target model. This routine was conducted for the three processes outlined above, resulting in an overall target cost-effective model, comprised of over 25 variables.

The components of the proposed cost-effective content development model were described and illustrated in Chapter 5 (Section 5.4 and Figure 5.4). The proposed model covers the three main processes of learning content development namely; learning content planning and design, learning content development, and learning content publication and evaluation. For each process through combining different suitable development strategies identified variables are organised within the proposed model so that the resulting learning content bears the minimum overall cost. In addition, Open Source Software (OSS) packages are adopted in the proposed model to reduce the development cost even further.

Chapter 6 covered hardware and software specifications of an experimental platform that was designed and implemented in this thesis in order to verify the practicality and functionality of the proposed model. A case study was carried out on this experimental platform to illustrate the conversion of an existing course notes in digital format into SCORM-conformant learning content, by following the proposed cost-effective model. Experimental results showed standards-compliant of the experimental platform, and indicated a good potential for the platform that could support the usage of the proposed model for the design, development and publication of learning content at minimized cost for tertiary education purposes.

In brief, development strategies chosen for three processes of learning content planning and design, learning content development, and learning content publication and evaluation along with the expected outcome of the proposed cost-effective model both match the definition of ‘cost-effective’ as mentioned in Chapter 1 (Section 1.2).

Therefore, the proposed cost-effective content development model has met the objectives of the project outlined in this thesis. However, to move towards a model that takes into account all variables and offers an optimum cost for learning content further work is required.

7.2 Future Work and Recommendations

During the investigation of this project, two efficient approaches to achieve cost-effective learning content were found: one is to simplify the learning content development process, and another is to design and implement a unified e-Learning platform for content development. The further work suggested for this project could combine and optimize these two approaches.

The effectiveness of the proposed model should be evaluated according to its outputs, but it is not always easy to calculate the cost savings of learning content development. Therefore, collecting relevant data and feedback becomes very important for computing the Return on Investment (ROI) and improving the development strategies adopted in the model.

Furthermore, the case study conducted in this thesis showed that a unified e-Learning platform could save unnecessary costs and efforts during the learning content development process. Therefore, a complete standards-compliant e-Learning platform consisting of a Learning Object Repository (LOR) and an integrated Learning Content Management System (LCMS)/Learning Management System (LMS) should be designed and implemented. To enhance the reusability feature of Learning Objects, such an e-Learning platform should comply with the latest SCORM 2004 3rd edition and support IMS QTI 2.1 specifications. These additions, however, could increase the complexity of the new target experimental platform.

Moreover, the designed Learning Object Repository should not only provide the functionality of distributed digital libraries over the Internet, but also offer plug-ins with the integrated Learning Content Management System/Learning Management System to enable instructional designers and instructors to search and retrieve Learning Objects upon the needs for the desired learning content. It is well known that the Learning

Object Repository should play an important role in enhancing the reusability of Learning Objects and facilitate cost-effective learning content development.

As it was mentioned in the conclusion, the proposed model is most relevant to technology and engineering programs. The model presented in this thesis can be enhanced by incorporating issues associated with Problem Based Learning (PBL) technique that is widely used in engineering discipline. It is envisaged that based on the work completed in this thesis, achieving a model offering an optimum cost structure for design, development, publication and evaluation of digital learning content is possible provided more theoretical research and development works both in pedagogy and formulation of variables discussed in this thesis are conducted.

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