Identification and prioritization of variables that influence learning content development in e-learning platforms

Zhengui Wu
University of Wollongong

Parviz Doulai
University of Wollongong, parviz@uow.edu.au

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Identification and Prioritization of Variables that Influence Learning Content Development in e-Learning Platforms

Zhengui Wu
School of Electrical, Computer & Telecommunications Engineering (SECTE) Faculty of Informatics University of Wollongong Wollongong, NSW 2500, Australia E-mail: zgw998@uow.edu.au

Parviz Doulai
School of Electrical, Computer & Telecommunications Engineering (SECTE) Faculty of Informatics University of Wollongong Wollongong, NSW 2500, Australia E-mail: parviz_doulai@uow.edu.au

Abstract—E-Learning is widely used to facilitate and enhance learning in higher education. For developing any e-Learning program, direct and indirect costs associated with digital learning content should be measured. Normally, over 60% of total e-Learning costs are spent on design, development, publication and evaluation of learning content. However, the rapid growth of high quality digital content has become a challenge to tertiary education institutions.

This paper discusses the employment of new technology known as learning objects for creating cost effective learning content. By investigating essential factors that affect learning content development, variables influencing the development cost are identified. Identified variables associated with content development process are prioritized based on the extent and significance of each variable in the context of 'cost'. Through taking control of these seemingly controllable variables, the content development cost can be minimized and thus cost effective learning content can be created.

Keywords—learning object, development cost, variables

I. INTRODUCTION

Over the last few years, the e-Learning market and industry has rapidly expanded. The U.S. e-Learning market was worth $17.5 billion in 2007, and it is expected that the global e-Learning market will continue to grow and surpass $52.6 billion by 2010 [1]. Along with the growth of the e-Learning market, an increasing demand for digital learning content has hence emerged.

Many instructional organizations and higher education institutions invest a great deal of time and energy into developing learning content for e-Learning.

Generally, design, development, publication and evaluation of learning content may account for up to 60% of the total cost of e-Learning development [2]. Therefore, to reduce the development cost of e-Learning programs, developing cost-effective learning content has become a new challenge to tertiary education institutions. For example, packaging high quality learning materials as Learning Objects (LOs), making them sharable and reusable in an Internet accessible Learning Object Repository (LOR), retrieving and aggregating related LOs into learning units within Learning Content Management System (LCMS), and then publishing to learners via Learning Management System (LMS) presents efficient methods to solve this issue [3].

In this paper, variables that influence the cost of learning content development are identified and prioritized. The impacts of these variables on the process of learning content development are investigated and documented in order to find an effective way to minimize the content development cost and thus develop cost effective learning content.

II. IDENTIFICATION OF VARIABLES THAT INFLUENCE THE COST OF LEARNING CONTENT DEVELOPMENT

As a new concept in digital learning content development, the LO has attracted broad attention within the e-Learning industry. According to the IEEE Learning Technology Standards Committee (IEEE/LTSC), a LO can be defined as "any entity, digital or non-digital, that may be used for learning, education or training" [4]. David Wiley more specifically described a LO as "any digital resource that can be reused to support learning" [5]. This definition somewhat narrowed the IEEE’s definition whilst emphasizing on the reusability of LOs.

According to these definitions, Reusable Learning Objects (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 material with concentrated learning experiences. In this case, the RLO has been broken down to a lower granular level: larger learning units can be formed by aggregating these self-contained RLOs. Moreover, because the created LOs can be reused in different courses which have common elements in the course content, rapid production and publication of online courses has become possible, hereby development costs can be minimized.

However, as with any digital content development project, the development cost of RLOs is affected by the numbers of variables. To minimize the cost of learning content development, variables that influence the development cost should be identified. In this paper, 10 variables that directly or indirectly influence the learning content development cost are identified based upon the common practices of LO creation. Identified variables that encompass both pedagogy and technology related matters are listed below and illustrated in Fig. 1.
To establish an entire content development project plan, instructional designers commence with the selection of an educational model where the delivery method of learning content is firstly determined. Then, the standards that will be used for developing the LO are decided upon, including standards for content structure, packaging learning content, metadata schemes, administrative systems, and assessment. Based on the selected standards, production and publication technologies are then chosen. This step may require the purchase of computer hardware, software tools and e-Learning platforms that produce or publish learning content.

After the standards, subject matter experts start to design the learning objectives, structure, and sequence of 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 each LO and the desired interactivity level should be clarified by subject matter experts. Authorized learning resources may also be adopted in the content to facilitate positive learning outcomes.

Subsequently, according to different quality requirements of 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 appropriate evaluation methods. All determined development strategies of the identified variables are recorded and documented in the detailed design documents. Based on these detailed design documents, the project manager can then complete the project plan, which includes scheduling the development time, assigning the work to different personnel and estimating the probable project budget.

B. Learning Content Development Process

Project plans should be executed after the design phase where the learning content will be produced and delivered to the target learners. To produce learning content, the development process will follow the detailed design documents established in the design phase. Fig. 2 illustrates the flowchart of LO development with identified variables. Because each LO is a small, self-contained ‘chunk’ of
learning materials with one learning objective, developing learning content as LOs for a whole course will require repetition of some steps in the development process.

The creation of LOs is based on the selected educational model, which provides infrastructure for the learning content development. To produce the learning content, useful raw learning materials are collected and classified. But before using these learning materials, copyright checking is required: learning materials come from different resources, hence copyright checking can ensure that the copyright of these materials is appropriately acknowledged thus avoiding potential legal problems.

After the copyright checking, the raw learning materials are sorted and saved into different folders on the computer based on the different learning objectives. Programmers and graphic artists start to process these learning materials using tools such as text editors, web editors and media editors to accelerate the process. Based on the determined interactivity level of the LOs, graphic artists add or delete media files and convert multimedia files into appropriate sizes and formats.

Based on the detailed design documents, the content author chooses the courseware development standards, content packaging, and metadata schemes. The prepared learning materials are subsequently imported into the authoring tool. The LO structure is built and relative resources are linked, followed by the tagging of metadata to describe the characteristics of the LO. Content author can then previews the produced LO, exported the LO from authoring tool and encapsulate the LO into a zip file.

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

To prepare the learning content for an e-Learning course, LOs that support the learning objectives of the course are located and retrieved from the LOR. The subject matter expert then imports the retrieved LOs into a LCMS and through the LCMS, the subject matter expert modifies and organizes these LOs into learning sequences. Sequential LOs are combined, packaged and exported as content aggregation packages, and then an e-Learning course integrated with these content packages will be created and published to the learners in the publication process.

C. Learning Content Publication Process

During learning content publication, an e-Learning platform consisting of hardware and software is setup. An e-Learning course integrates with the course content and related practices are created on the LMS and released to target learners. As soon as the online course is published, an evaluation that focuses on the learners’ learning processes and outcomes is implemented. The flowchart of learning content publication process is illustrated in Fig. 4.

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

After determining the bandwidth, an integrated e-Learning platform, which typically includes a web server, database, and LMS, is built for publishing the e-Learning course and offering a virtual learning environment for instructors and learners. Based on the detailed design documents, the subject matter expert creates an e-Learning course on the LMS and imports related content packages into the course. After the learning content is placed on the LMS, an interactive learning environment that includes learning activities and practices is built to enhance the learning experience and facilitate learning outcomes.
Before releasing the online course to target learners, the quality assurance technician will check the quality of the entire course to ensure the reliability and practicability of the online course. The quality inspection includes checking for the learning process, practices, and learning performance. After quality checking, the online course is published and released to target learners. Meanwhile, the evaluation mechanism starts working to track the learning progress of each learner and collect useful data: these statistics and assessment results can be used to evaluate the quality of the learning content.

IV. PRIORITY OF IDENTIFIED VARIABLES IN CONTEXT OF COST

Identified variables characterize and differentiate the diverse e-Learning technologies that are involved with content development. To derive a technical method to reduce the cost of learning content development, the impacts of the identified variables on the development cost are investigated. In the following, the prioritization of the identified variables in the context of ‘cost’ is detailed with the potential solutions for minimizing the development cost of each variable.

A. Educational Model

Because the entire learning content development process is based on the selected educational model, the educational model is the first prioritized identified variable. The educational model embodies learning theories, proposes methods of learning, and specifies the delivery method for the created learning content. If a suitable educational model is adopted to produce the learning content, the development process can be simplified.

In Web-Based Training (WBT), a distributed learning model is widely used as default model for content development and publication. The economic benefit of the distributed learning model is that the development costs are distributed over a larger numbers of learners, thus increasing the efficiency of the development cost [6].

B. Standards

‘Standards’ is another variable involved in the entire learning content development process, thus it should be the second variable prioritized. LO standards define a common model that not only allows LOs to offer features such as reusability, accessibility, and adaptability to the target learner, but also provides interoperability between various administrative systems such as LCMS, LOR and LMS [7]. LO standards can be considered as an important component of the e-Learning infrastructure. Selected standards could affect the purchase of learning content production and publication hardware and software, which are major investments in the learning content development process.

Currently, the Sharable Content Object Reference Model (SCORM) is the most popular content component model in e-Learning and is widely adopted 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 [8]. SCORM-compliant LOs can work with every SCORM conformant LMS, which enhances the reusability of the learning content and reduces costs and efforts that are spent on converting learning content across different e-Learning platforms.

C. E-Learning Platform and Production Technologies

Normally, more than half of the content development cost is spent on the production and publication technologies. Therefore, the e-Learning platform and production technologies are prioritized after standards. Choosing the most appropriate e-Learning platforms and production tools for learning content development can accelerate the development process and thus result in considerable savings on the development cost. In addition, as an important component of e-Learning, the investments into the e-Learning platforms are significant: the platforms may initially charge according to the 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 production technologies.

However, there are some Open Source Software (OSS) packages that help the content author to produce LOs, with similar functionality compared to commercial packages. As OSS are free to download and use, adopting these OSS packages can minimize the cost of learning content development and are an alternative to commercial software.

D. 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 are the primary factors affecting the content design and publication in e-Learning. To avoid long download delays for learners, the available bandwidth should be estimated when designing the learning content as it will constrain the LO size and interactivity level. In fact, decreasing the file sizes of the learning content, achieved by reducing audio and video utilization in the learning content and using bandwidth-friendly file formats [9], could be an effective way to reduce the downloading delays.

Moreover, for learning content publication, investment in a high-bandwidth connection between e-Learning servers and the Internet is required. High bandwidth can provide good learning experiences for the learners, thus enhancing the effectiveness of the learning content. According to the Australian flexible learning framework, the minimum bandwidth requirement is 1Mbps downstream for 10 learners accessing content that is embedded with audio and video, but ideally four times this amount can provide a better and more satisfying learning experience [10].

E. Interaction

Interaction is a major feature of e-Learning. Most instructional institutions desire highly interactive e-Learning courses to both engage and motivate learner involvement to facilitate learning outcomes and knowledge retention [11]. S. Codone [9] defined four interactivity levels to evaluate learning content in e-Learning: low, moderate, intermediate and advanced. 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 designed as it directly affects the cost of learning content development.

F. Modularity

In contrast to traditional digital learning content, reusability is often the most attractive feature of LO. The value of the learning content increases every time when it is reused, and the development cost is also saved by avoiding new LO design and development time. Moreover, the possibility of selling RLOs or sharing them with partners creates new business opportunities for the e-Learning market.

To enhance the reusability of a LO, the LO modularity should be taken into account, which includes the granularity of the LO and tagged metadata. The granularity is the size of a given ‘chunk’ of learning material. If the ‘chunk’ is too large, it is difficult to reuse the LO in the future. Conversely, if the ‘chunk’ is too small, it will increase the time and costs of development. Therefore, determining suitable granularity for each LO can enhance the reusability of the created learning content and hence reduce the development cost.

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.

G. 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, assess the actual return on investment (ROI) of the content development, evaluate learning outcomes and collects valuable feedback such that the content can be continually improved [12]. The successful design of the structure and content of a LO can be reflected upon in the evaluation results.

The steps of the evaluation process normally include defining the objectives of the evaluation, selecting the data collection methods, and determining the methodologies and required technologies of evaluation. Kirkpatrick [12] defined a four-level evaluation model for assessing the impact of the learning experience. These four levels are learner reaction, knowledge transfer, behavior transfer, and organizational impact. The cost of evaluation will increase when selecting higher level objectives during the evaluation.

H. Quality

Obviously, choosing appropriate development strategies for the identified variables can lead to quality outcomes in the content development. However, costs and time spent on quality assurance and improvement during the development process are still required in well-funded learning content development projects. The composite aspects of quality control and inspection in e-Learning include quality inspection for learning resources, created LOs, learning processes and practices, and learning outcomes. Such quality inspections can reduce the accessibility problems within the created learning content and e-Learning course, thereby offering better learning experiences. Further, because the quality of the learning content can be ensured, the reusability of the content is also enhanced.

I. Copyright

The impact of copyright on the cost of learning content development is dually motivated. Firstly, learning materials originate from different resources, hence they 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 copyrighted learning materials, purchasing licenses or
obtaining the copyright permissions from the authors is required. Secondly, the copyright of the created learning content should be protected and many digital copyright and licensing applications can be used. Because a typical LMS often provides a registration and authentication system, these applications have become an alternative to instructional designers thus copyright has less of an impact on the cost of learning content development.

V. CONCLUSION
The purpose of this initial study is to identify and prioritize variables that influence the cost of learning content development with the aim of trying to minimize the development cost in a technical manner. During the investigation, the features of LO indicate a possible solution to produce cost-effective learning content. Concentrating on developing digital learning content as self-contained RLOs, 10 variables which directly or indirectly influence the development cost are identified. In line with the three main processes of content development, the development flowcharts associated with the distributed variables are drawn to describe the relationships between identified variables and each development phase. To prioritize the identified variables, the impacts of each variable on the development cost and potential solutions for minimizing the development cost are investigated and summarized.

Current research efforts focus on the construction of a cost-effective content development model that consists of controllable variables. Assigning suitable development strategies to these variables in each content process is an efficient way to minimize the development cost and help content authors to design, develop and publish cost-effective learning content. In addition, adopting open source software in learning content development is suggested: offering similar functionality to commercial software but with free download and use, adopting these software packages result in considerable savings on the cost of purchasing production and publication software and thus the overall costs are minimized.

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