Educational Resources as Digital Products

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Abstract. In the paper educational resources are treated as regular digital products. The problem of the production, distribution and sale is addressed, especially concentrating on the production effort, cost and price. An original method of estimating development effort of e-learning resources is described and experimental results are presented. The paper presents also two extensions of the existing structure and implementation of learning objects. The structure of a learning object, although flexible, focuses on reuse, which is insufficient for independent learning. Therefore the first extension is the concept of a teaching object that contains all parts of the educational process, from knowledge presentation, through examples and exercises to final examinations. A teaching object is proposed as an independent subject of sale. Addition of data access methods to learning objects is the second proposed extension that creates a learning component. A model of learning object distribution based on Web services and learning components is proposed.

1 Introduction

Education is a part of global and national economy with its products, markets and competition and also with overproduction and pricing problems. The use of information technology and Internet in education has resulted in a rapid development and globalisation. The IDC experts predict that the e-learning market will rise to $21 billion in 2008 from $5,6 billion just two years ago [1].

E-learning supports traditional education on the primary, secondary and university levels, while dominating in some areas like re-education and self-training. The learning process placed in the Internet causes concentration on educational resources, as teacher and learner are distant in time and place. To act as digital products, educational resources must conform to three rules: must be divided into structured units, that can be an independent subject of sale, must have precise calculation of cost and price and must be represented in a technology that allows for effective Internet distribution. The three areas are addressed by the research presented in the article. The use of new Internet technologies is proposed to increase interoperability and usability of educational resources. The presented solutions apply to digital educational resources production, distribution and sale.

2 Characteristics of Educational Resource Market

The e-learning market is not growing as fast as it was expected to, partly because of payment problems in distance education and other Internet-based domains. The Internet supplies extensive and free of charge data that can be used for education. Unfortunately, the data is often unsuitable in its contents or presentation, which results in the development of chargable educational resources. The learner demands fast and effective methods of education that cope with the changing work market.

Currently, universities are main e-learning centres. Although Internet is used as the learning environment, the education process has not changed. One institution is responsible for resources production, delivery, examination and certification. The evolution of markets usually results in specialization, which can also be expected for e-learning. In the future, the separation of educational resource production, delivery and certification is expected [2]. The vision of future e-learning market is shown in Figure 1.

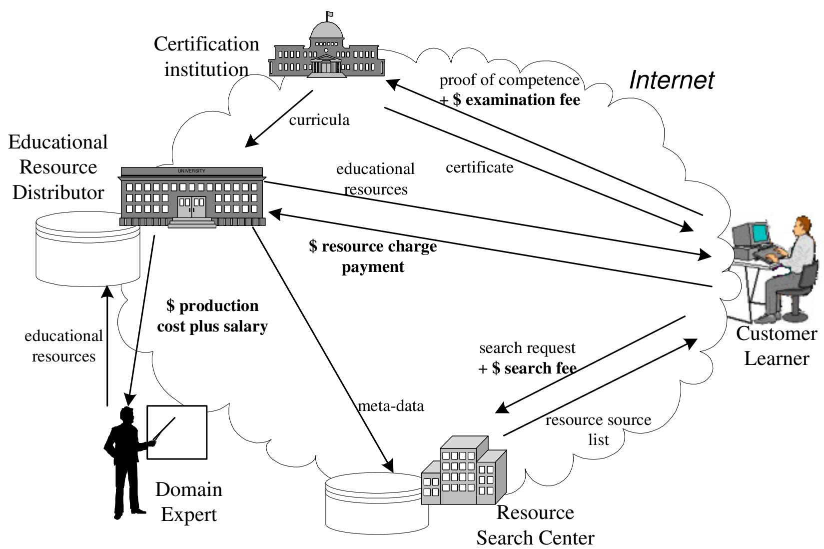


Fig. 1. Characteristics of future e-learning market

Five roles on the e-learning market can be distinguished: the learner, the domain expert, the educational resource distributor, the resource search centre and the certification institution. The process starts with the domain expert, who produces educational resources and delivers them to a resource distributor. The resource distributor checks the curricula given by the certification institution and calculates the educational resource price. The domain experts are paid for their work.

The learner, who is the final customer, searches for the resource with the help of the search centre and purchases required resource from the distributor. When the learning process is completed, the learner can pass examinations and get a certificate from the certification institution. The learner pays separately for the course and for the certification, as it is now with language education. In this solution a student selects the best resources from a university in England, learns it with the help of a teacher from Poland and then passes examinations on a university in Spain, that is closest to his place of living.

In e-learning, the role of universities changes, as they are responsible for curricula definition and certification. Universities can also play a role of educational resources producers because their employees are usually domain experts with pedagogical experience. However, universities are one of the resource offerents, competing with each other and with commercial organizations.

The preparation of high quality resources appropriate for the Internet delivery is difficult and labour-consuming. Therefore, domain experts demand high fees for their work. Additionally, the existence of digital lectures reduces significantly the importance of the lecturer. There is a problem, how to estimate the cost of educational resources production and how much the producer must be paid for it. On the other hand, the learner demands low prices and high quality resources. Apart from pricing problems, copyright violations threat the educational resources sale process. Effective methods of resources protection are highly required.

3 Educational Resources Production

The technological and thematic diversity of information in the Internet causes storage and search problems. One of the most effective ways of knowledge organization is its division into smaller units described with metadata. Many e-learning standards and specifications have been developed to enable the cooperation between different users and systems. A learning object is defined as the primary educational resource unit in e-learning.

3.1 Learning object structure according to standards and specifications

There are two main learning object specifications: the IEEE/LTSC P1484 standard and the Sharable Content Object Reference Model (SCORM). The IEEE standard defines a learning object as: any entity, digital or non-digital, which can be used, re-used and referenced during technology-supported learning [3]. The definition is very broad and has been criticized for that [4]. The SCORM definition of a learning object is SCO (Sharable Content Object): a collection of one or more assets that include a specific launchable asset that utilizes the SCORM run-time environment to communicate with Learning Management System (LMS) [5]. The definition is narrowed to SCORM-compliant resources. The SCORM describes the data structure for learning objects as a combination of digital contents, metadata and structure description. The basic idea of a learning object and its SCORM representation are shown in Figure 2.

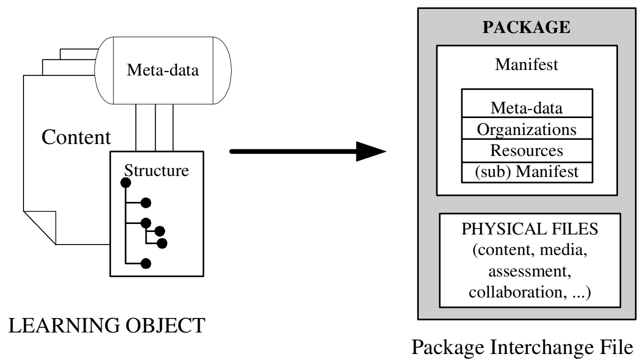


Fig. 2. Learning object structure according to SCORM specification

The SCO unit consists of assets, which are electronic representation of media, such as text, sound or image (HTML files, XML files, Flash objects etc.). The basic requirement is that an asset is readable by a Web browser. A set of assets is given a manifest file that provides the meta-data, assets organization structure and resources description. The meta-data is the base for an effective search and is the subject of many standards. Manifest file and physical files representing assets are packed into one PIF (Package Interchange File).

3.2 The concept of teaching object

Learning objects can differ significantly in their size and scope taking the form of a single image, a definition, a piece of text, a listing, a lesson, the whole course, an e-book etc. Standards represent a teacher-oriented approach in which re-usability is emphasized. Therefore, fine-grained objects are preferred e.g. a simple picture or a piece of text. The approach is suitable for teachers, however, it does not fulfil the requirements of learners.

A learner uses e-learning technologies for re-education and self-learning, which requires individualization in courses preparation and precise problem solving (e.g. how to parse XML with Java). The required size of a learning object is closest to a lesson unit. Therefore, in the presented research a new term of teaching object is proposed.

A teaching object is a type of a learning object that represents an interactive knowledge unit of a complete lesson scope on a certain subject. A teaching object provides the lecture together with practice and tests. The idea of a teaching object in comparison with a learning object is shown in Figure 3.

The teaching object structure is created with the use of educational process theory. The word "teaching" is used to emphasize that it teaches the learners, guides them through a piece of subject.

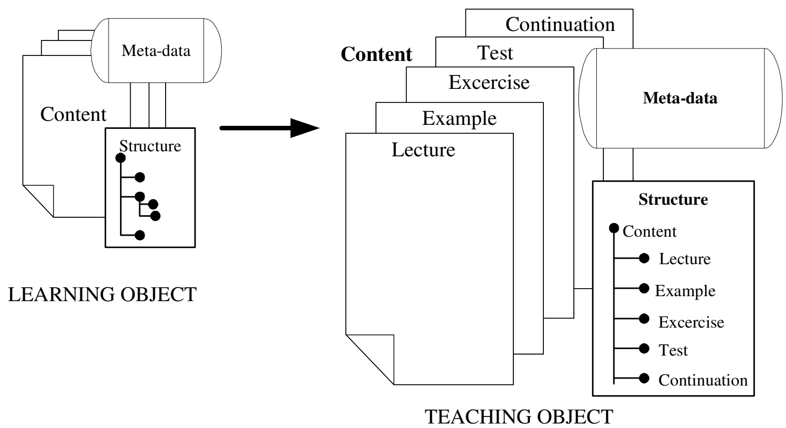


Fig. 3. Learning object compared to teaching object

The teaching object content consists of a Lecture part for reading or watching and interactive Examples, Exercises and Tests. Interactivity of educational resources is necessary, which is supported by IMS Question, Test and Interoperability specification [6]. The Example part is a task made step-by-step with guidelines available if the user does not understand a phase of a solving process. The Exercise part is a task that should be made individually by a student and compared with the final answers, with some hints available, but the entire process not explained. The Test part enables self-testing, while the Continuation part allows to choose the next step in the learning path.

Good e-learning resources must consider psychological and pedagogical issues. Two special problems arise: the lack of teacher and the limited concentration abilities. The first problem causes learning effectiveness to decrease because of low self-discipline of the student. Therefore, the interaction with educational resources, as proposed in teaching objects, is important because it stimulates verification. A traditional face-to-face lesson uses a combination of lecture, example, exercise and test, which is adopted in teaching objects. Not all interactive parts of a teaching object are required, e.g. subject introduction usually does not contain exercises. The Lecture and Test parts are obligatory, while Example and Exercise are strongly recommended for teaching objects. The optimal time of learning with a teaching object is 20 minutes, which is the approximated time of human brain concentration. The teaching object concept does not, however, impose any time constraints.

A teaching object can be represented using standard structures, however, in comparison with a learning object it is more learner-oriented. A lecture together with tasks and a test, makes a complete interactive knowledge unit that can be an independent subject of sale.

4 Effort, Cost and Price in Educational Resources Production

An effective calculation of costs and prices is necessary in all commercial projects. The notion of effort means the amount of work required for the production process. The cost is expressed in financial units and involves the effort, the value of work unit and the value of resources used. The price is the actual amount of money paid for goods.

4.1 Characteristics of Educational Resources as Digital Products

A learning or teaching object is a typical digital product: virtually indestructible, easy to modify and almost costless to copy. The cost of design and first-copy production for educational resources is expected to be over 70% of the total cost, as it is for other electronic products [7].

Educational resources contain data and interaction definition and are implemented using XML and scripting languages, therefore their physical representation is a combination of application code and text. Human work is the main resource used for production of digital products. Learning object costs result mainly from effort similarly to software. There are many different methods of effort estimation in software engineering. Most widely known methods are parametric models such as COCOMO (Constructive Cost Model) [8,9]. The basic size metric of software code is the standard line of code (SLOC) [10]. The methods are partly applicable to learning object effort estimation.

A learning object is an intellectual product with the author copyrights guaranteed by law. Therefore, it may be compared with art, film or literature. Explicit pricing and effort measurement of such products is difficult. It is impossible to estimate the value of idea with effort estimation methods [11]. But typical XML or HTML code is not so complex and valuable as art and, therefore, may be priced with standard rate.

4.2 Effort Measurement of Learning Object Production

Effort estimations are mainly based on product size and complexity. Learning objects are viewed with Web browsers, which means that one webpage is a good metric of the size of single knowledge unit provided to a learner. In the paper the number of standard pages is proposed as the basic metric of learning object size. Pages differ in resolution, formatting, font sizes and other features, therefore, the standard page is defined as 25 lines, each filled with 60 characters including spaces. The main advantage of the metric is the simplicity (the number of characters including spaces is counted and divided by 60x25). The metric of standard page is not dependent on learning object technology and uses document sizing techniques [10]. Educational resources are often made with tools that generate the XML code automatically, however, the metric measures the final product of the delivery and not its code representation.

The defined metric was used in effort and size calculations of sixty learning objects created by four independent developers. Generally, there exists a high correlation between the effort required for the production and the final object size, as shown in Figure 4.

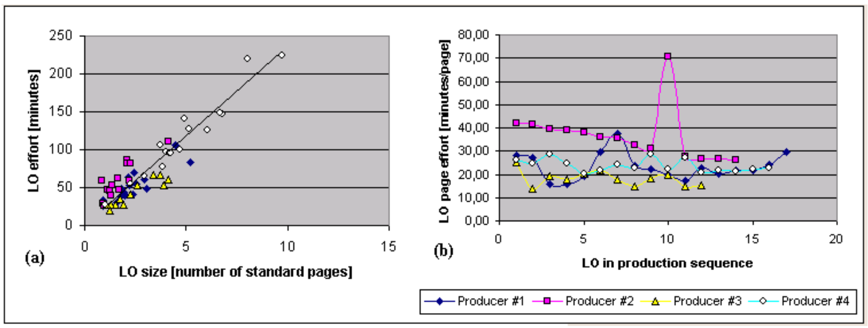


Fig. 4. Effort and size of learning objects production - measurement results

Figure 4a shows the correlation between learning object production effort and size. The first observation is that learning objects, although standardized, may differ significantly in size. The linear correlation coefficient value is 0.92, which means strong positive correlation between the two variants of size and effort.

Figure 4b shows the effort per standard page for the measurement results. The producers were not experienced in XML learning objects development, which is reflected in a speedup during the development of final pages. The effort of a single page development converges to the average for all producers. The average effort per standard page is 25,58 minutes with the deviation of 36%.

Most of the estimation parametric models transform the size metric to the effort with the use of equation that characterizes size to effort relationship. The metric of standard page is used to estimate the effort of learning object development. The exponential function characteristics bind the code size and effort for software. For the learning objects production, the function characteristics are linear. The effort can be estimated with the Formula (1).

$$Effort_{LO} = CF \times E_{sp} \times Size_{LO} . \quad \textbf{(1)}$$

where

$Effort_{LO}$ - the effort of learning object production in manminutes,

CF - the correction factor,

E_{sp} - the effort per standard page rate based on average result,

$Size_{LO}$ - the learning object size in number of standard pages .

The correction factor CF can consider: the use of tools for code generation, the technology difficulty, re-use and producer experience. The effort per standard page rate E_{sp} may vary depending on certain learning object models. The estimation method must be validated on the effort and size data specific for the institution.

4.3 Learning Object Effort Versus Cost and Price

The knowledge about the effort of learning object development is sufficient to calculate the development cost. Cost is obtained by multiplying the effort by the manhour rate. The rate depends on the country the resources are produced in; therefore the metric of effort is more representative for comparisons than cost.

In theory, the price can be based on four factors: natural value of resources used, product usability, production process cost and product rarity. There are almost no resources used in learning object production, so that factor does not influence the real value of a digital product. Learning object production costs result mainly from human work costs, which can be predicted with effort estimation methods. The price of educational resources depends mostly on the usability and rarity. The usability of learning object results from its quality and learner-orientation, while its rarity results from the subject and didactic delivery techniques.

5 Educational Resource Distribution Model

The main idea of the resource distribution model presented in the article is to transform existing learning objects into learning components based on the Web services technology. According to standards a learning object is a set of structurized data. The proposed transformation adds an interface to a learning object to create unified and platform-independent data access methods. Getting and setting operations are present in many objects, which allows to manipulate the data encapsulated within it. The methods can be applied to learning objects, what creates a learning component. The idea of learning component is shown in Figure 5.

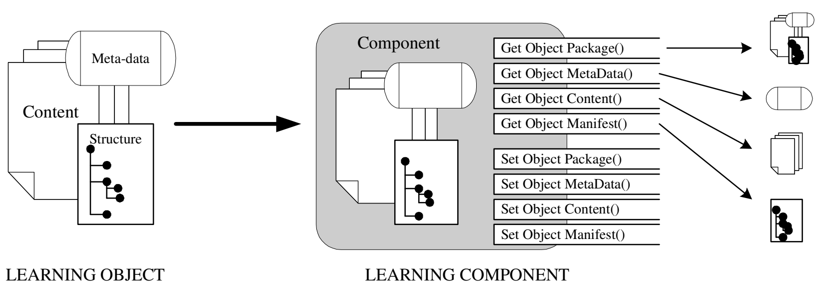
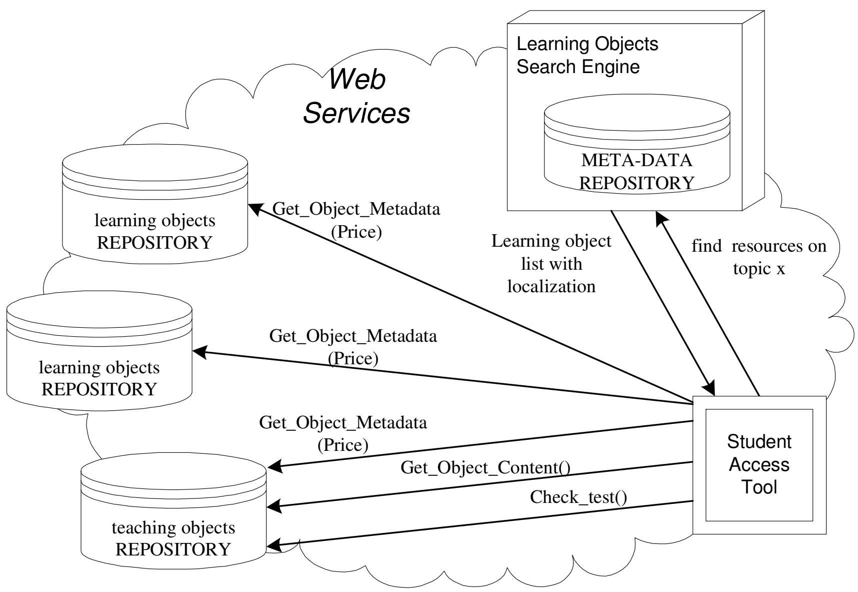


Fig 5. Learning object representation as learning component

A learning component is equipped with a set of methods. Get_Object_Package() and Set_Object_Package() methods implement the exchange of the whole learning object. The other get methods are used to get a part of a learning component without getting and unpacking the whole package e.g. the price attribute is included in the metadata and can be read with Get_object_metadata() function. The method Get_Object_Content() is used when opening an object with a browser not supported with LMS. Corresponding set operations are also available.

The diversity of learning objects content results in the variety of their behaviour. Other methods can be defined for different learning object types. A teaching object, as one of the types of learning objects, can be also represented as a learning component. Additional methods for a teaching object can be proposed such as Get_one_random_test_question() and Check_test(), which allows to make an examination from teaching objects that create the whole course.

The learning component functionality is implemented as Web services, which makes it independent of technology. The model of learning objects distribution is



shown in Figure 6.

Fig. 6. The model of learning object distribution based on learning component methods

If learning objects are published in the Internet, a protection against illegal copying must be enforced. An access to the whole learning object package by an unauthorized user may result in an easy replication and an unauthorized use. Access rights verification is easy to implement because object data is accessible only through object methods, e.g. Get_Object_Content(). Although one may attempt to reconstruct the whole object from the partial data acquired with object methods, the process is much harder to perform. Method visibility determines, whether methods are publicly or locally available. Methods that allow an easy search of learning objects such as Get_Object_Metadata() or Get_Object_Method_List() can be public. Methods concerning data with copyrights, e.g. the content, can be restricted, which means that their use will be limited to authorized users. Internal methods can be reserved for the repository owner. The internal methods include set operations and the Get_Object_Package() method that can be used for replication between repositories. The proposed visibility is useful if learning objects will be highly protected. The solution improves the interoperability and simplifies data search and copyright protection.

6 Conclusions

The growing number of commercial resources available in the Internet enforces precise cost/benefit calculations of digital products. Educational resources can be measured with a simple metric of a standard webpage, which enables effort and cost estimations. The presented research has shown, that the effort required to create one standard webpage is constant. Further research has to be done to validate the data and to identify potential factors that influence production costs.

The efficiency of learning objects can be increased with the use of a new concept of teaching object that supports the whole learning process. The distribution of teaching and learning objects is simplified by using learning component concept and Web services. The implementation enables high interoperability and copyright protection.

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