RLO in e-Learning Solutions

Daniela Velichová
Institute of Natural Sciences, Humanities and Social Sciences, Faculty of Mechanical Engineering, Slovak University of Technology, Nám. slobody 17, 812 31 Bratislava, Slovak Republic
daniela.velichova@stuba.sk

Abstract

Paper brings short information about reusable learning objects - RLOs as new conceptual phenomena in e-learning pedagogy. Basic characteristics of RLO development and usage in teaching and learning mathematical subjects with the support of e-technology are presented, aimed to enhance better conceptual understanding and to introduce some from the numerous advantages of the ICT in the mathematical education.

1. Introduction (12pt, bold)

Since the Internet has become a widely used educational environment, education communities have at first adopted a concept of creating educational materials in the form of the complex full text electronic courses, comprising all course material in large educational modules. Traditionally, content came in a several hours chunk called a course. Currently a new concept for e-learning has been adopted, and it is the object-based learning. This approach is a new way of thinking about instructional content. The idea is to decompose existing course material into smaller units, so-called "learning objects" [1]. Learning objects are self-contained, modular pieces of course material appropriately annotated with metadata. They may be combined to form larger educational interactions, e.g. traditional modules, but in a modular way. The goal is to develop an open architecture for online learning that will allow teaching to be centred on the needs and interests of the learner, enabling learning to occur anytime, anyplace and to allow for greater customization and flexibility of the learning environment.

Learning objects have emerged as instructional technology's new paradigm. This idea has gained such broad acceptance that the IEEE has formed the Learning Technology Standards Committee to pursue the creation of common standards for the description, interchange, and management of learning objects. As time passes, eventually object-based technologies are replacing classical instructional design approaches. This leads to reuse, and reuse leads to faster development and higher quality instructional contents. In addition, as object-based systems are easier to adopt and easier to scale, different re-assembling of reusable learning objects can create large and colourful instructional materials.

There can be find many terms that are used in the literature besides „learning objects„ by IEEE Learning Technology Standard Committee (1). Other terms that imply the general intention to take an object-oriented approach to online learning are ”knowledge objects”, ”pedagogical documents”, ”online learning materials”, and ”educational software components” (see in [2], [3]). The Learning Technology Standards Committee had chosen the term "Learning objects" to describe these small instructional components and provided a working definition: "RLO is any entity, digital or non digital, which can be used, reused or referenced during technology supported learning".

This paper aims to describe how reusable learning objects might be used in teaching Mathematics with e-technology, enhancing better conceptual understanding through introducing some from the numerous advantages of the ICT utilisation in mathematical education. Few comments on the design of data-driven reusable learning object-based materials that meet the learners and instructional design requirements are given. First some background and key aspects of learning object design principles and instructional properties are given. This is followed by an explanation of how reusable object-based lesson model with sound instructional design is defined. Several examples are then provided to illustrate how to implement the reusable object-based materials, modules or complete e-learning courses in the virtual www environment.

2. Learning objects in e-learning context

Currently, we can see more and more instructional content developed specifically to be deployed as learning objects in multiple learning contexts due to its potential for reusability, interoperability, discoverability, and manageability. There can be described two approaches to design the reusable object-based courses: first - by searching and using the existing instructional materials which can be considered as learning objects from the online learning sources, such as the Internet, second - design or convert the instructional materials into object forms. The key underlying principle of creating object-based lessons from learning objects is that sound instructional design practices must be followed. Standardized principles for design of learning objects and instructional properties are necessary in the design process so that instructional contents can eventually be used for facilitating intended learning outcomes and reused within and between different learning contexts at an appropriate level of granularity.

An instructional content is only considered as learning object if with the following instructional properties:

a) Learning objects must be instructional objects

A learning object is not just a piece of information. It must provide deliberate instruction at appropriated level with meaningful interaction, in order to retain skills or key concepts by the learner. Often if the object is an informational object, the intention is just to inform, but if the object is a learning object, then it will provide an environment that is much more conducive to facilitate learning and reinforce the recognition of skills or key concepts.

b) Learning objects must be relatively small

The learning objects for instructional contents should focus on a single learning objective, so that it will be relatively small, discrete or self-standing unit of knowledge to support flexible, individualized learning. It is important to note that simply being physically small does not qualify as a learning object. To equate a learning object, information or content must be small and focused. If each learning object is based upon a single objective, and the granularity is small enough, then each learning object will be "appropriately" small.

c) Learning objects must be extractable or stand-alone

A learning object must be self-sufficient to provide instructional information in the form of modular units and it must not rely on previously learned information, references or examples in order to clearly provide instruction on a concept (5). The lack of self-sufficiency is one of the reasons why most existing educational materials do not qualify as learning objects.

d) Learning objects must be usable on a standard platform.

Learning objects should work in a variety of standard Web platforms. It should require only web browsers and some common plug-ins which are available free for download from Internet for viewing objects created with Flash, Director, Shockwave, Java Applet, and Java Scripts. No prior software component installations should require other than those provided by the web browsers and operating systems.

e) Learning objects must be tagged and searchable

Learning objects must be shared, accessible and discoverable by others across learning environment, in order to be used, and reused widely to meet real-world performance criteria. They must be labelled as to what they contain, what they teach, and what requirements exist for using them so that users understand what a learning object is about without ever seeing them. Currently there are initiatives for building the metadata schema that will allow for the universal sharing of learning objects. Examples of existing metadata standard which can be used are Dublin Core Meta-data [4] and IMS Metadata [5].

A basic problem faced by the learning community is how to produce and deliver quality content for online learning experiences. Online learning content typically contains:

a) Text, tables, graphics, on-line calculations, or video shots and movies,

b) A navigation scheme (easily a table of contents and/or buttons).

It may also contain collaboration tools as well as other interactive elements and graphical elements designed to produce a unified or branded look and feel, abut the above list is basic.

To be learning content, the content should also be aware of learners. At a minimum, learning content should recognize who the learner is and record information about the learner's experience. To make this possible, learning content has generally been developed in conjunction with some sort of learning system that keeps track of learners. Learners log on to the system and launch the content. As the learners interact with the content, results are passed back to the system. If the system allows it, the content can also change its behaviour based on learner information stored in the system. For example, learners might be sent to different places in the content based on test scores, language preferences, learning style inventories, competencies, certifications, organizational roles, and other data.

Interoperability (content from multiple sources working equally well with different learning systems) and reusability (content developed in one context being transferable to another context) are imperative to the sustainability of the reusable learning object design. Without them, anyone with a significant investment in either content or a learning system is locked in to that particular content or system. Without them, every time a course, (whatever it is) or an interactive electronic training manual needs to be updated, far more of the material must be rewritten than is necessary or desirable. Without them, the process of developing high-quality content is prone to unnecessary duplication of effort, driving up the cost, possibly past what the market will bear.

Reusable learning objects represent an alternative approach to content development. In this approach, content is broken down into chunks. From a pedagogical perspective, each chunk might play a specific role within an instructional design methodology. The requirements for each chunk are:

- Each chunk must be able to communicate with learning systems using a standardized method that does not depend on the system
- What happens within a chunk is the chunk's business.
- How a learner moves *between* chunks is controlled by the learning system.
- Each chunk must have a description that enables designers to search for and find the right chunk for the right job.

Such chunks are called learning objects. There is no standard for the size (or *granularity)* of a learning object. Larger learning objects are typically harder to reuse, and smaller learner objects save less work for those who are assumed to reuse them.

For learning objects to be used they must be found. It is not easy to find anything in a large distributed online environment like the World Wide Web or a large intranet. The solution is to store not only learning objects but also descriptions of the learning objects. Thinking of the learning objects as data, the descriptions are data about the data, or metadata. Learning object metadata potentially includes information about the title, author, version number, creation date, technical requirements and educational context and intent.

3. RLOs in Mathematics

World Wide Web provides great opportunities to Math educators to utilize and create on-line educational materials. Not only text and picture, but also animation and sound can be used in educational materials on Internet. Learning objective, introduction, and summary are additional learning strategies, which must be designed and integrated into every RLO in order to create a complete instructional experience. Many companies made web-ready software, such as MapleNet by Waterloo Maple Inc. [6], which can be used to manipulate mathematical symbols and draw 2D and 3D graphs in browser windows, or the RLO-CETL, the Centre for Excellence for the design, development and use of learning objects [7], the partner institutions are London Metropolitan University, the University of Cambridge and the University of Nottingham. At the same time, interactive learning materials from individuals such as Java applets, and Flash are now growing rapidly on Internet. We might be able to find what we need in the near future, and utilize these educational materials for other purposes by making links.

MathML is a new way of encoding mathematics using XML developed under the auspices of the W3C (World Wide Web Consortium), the group that sets the basic standards that define the Web. A growing number of software packages including browsers, editors, computer algebra programs and publishing software use MathML to communicate. Unlike other ways of putting math in a web page, such as images and PDFs, MathML provides ways to directly encode various interactivity properties of an equation, which makes it an ideal choice for dynamic math on the web. When someone visits a Web page that contains math, Internet Explorer "sees" a document written in HTML containing MathML "islands" for each equation. Some information in the header of the document tells Internet Explorer that MathPlayer software is to be used to display and print the MathML islands. Internet Explorer loads and executes the Math Player software on an as-needed basis. Whenever Internet Explorer sees MathML, it gives it to Math Player to display on the screen (or print it). Equations can be copied to the clipboard as MathML and then pasted into any application that understands MathML or into a web editor. Drag-and-drop works similarly.

Among the applications that understand MathML are the popular computer algebra systems, Mathematica and Maple. In the near future eventually all mathematical and scientific software applications will support MathML. One of the advantages of embedding math in a web page using MathML is that it makes it possible for the maths to be spoken. This was always a goal of the W3C in order to make maths easier to understand by the visually impaired. Math Player 2 begins to realize that goal by providing the ability to speak the math in a web page. The user can do this by choosing *Speak Expression* on Math Player's right-click menu or, more importantly, via a screen reader application such as Window-Eyes or JAWS. In the current release of Math Player, the math-to-speech capability is fairly natural, as the main goal of math-to-speech technology is in teaching normally sighted students how mathematics is spoken.
Embedding maths in a web page using MathML also makes it possible for web searches to include the mathematics on pages, not just text.

Many Windows applications use Microsoft's HTML engine, MSHTML, to display formatted content. This includes email clients, alternative web browsers, weblog (RSS) clients, instant messaging clients, help engines, and so on. Because Math Player works by MathML-enabling MSHTML, MathML support is available in such applications literally for free. The only thing missing is a way to get MathML content into the HTML.

4. Examples of RLOs in EVLM Central Database

Many existing on-line databases contain reusable learning objects bringing instructional study material from different parts of mathematics. Majority of them work in so called „closed-shop" exclusively, and these provide access to the study material after the required login and password input. Among the few of those freely accessible on Internet, one can find EVLM - European Virtual Laboratory of Mathematics, product of the European project within the Leonardo da Vinci programme scheme for vocational training ([8], [9]). EVLM provides on-line database storing different types of e-learning materials distributed into several mathematical subjects and their related topics (Fundamental Maths, Algebra, Calculus, Geometry, Difference and Differential Equations, Multivariable Calculus, Probability, Statistics, Numerical Analysis, Optimisation and History of Maths) and according to material types (FACTs, RLOs, MODULEs and PROBLEMs). When learners needs a specific piece of information, they can navigate in the EVLM database by material type in a request, and get the relevant, only needed learning objects.

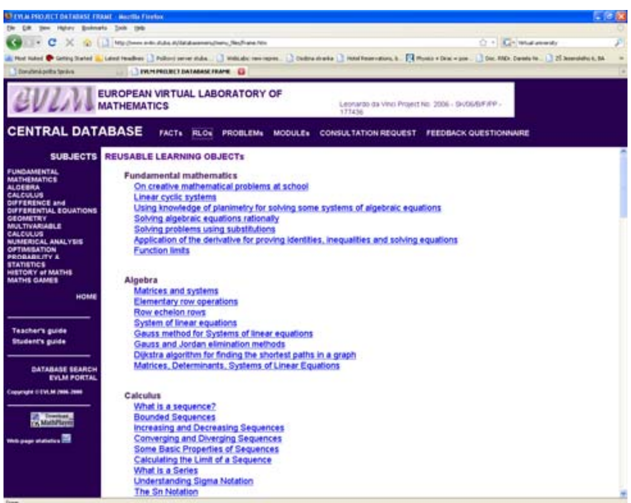

Fig. 1. List of RLOs in EVLM database

Fig. 1. shows the interface page to search the appropriate material type and the object details that appear at the learner's screen after retrieve from the repository. This particular object is a RLO web page reference that describes what different reusable learning object types of materials are available in the EVLM database repository. Besides being used to recombine to form larger educational interaction, e. g. modules in some particular geometric theme, each of these RLOs can be used by learners as an independent learning material to enhance certain concept, principle, mathematical relation or idea.

Most of the learners can use e-learning resources as a supplement to the traditional lecture and textbook and this would provide substantial benefits. Students at the Faculty of Mechanical Engineering, Slovak University of Technology were asked to indicate their interest in the ability to access the most updated learning contents from a pool of learning objects to tailor learning content for multiple learners, and to personalise learning content to the needs of individuals offered by object-based learning systems. In each case, a majority of students considered these capabilities to be highly beneficial. Because the learning object approach allows teaching and learning to be centred on the needs and interests of the learners, enabling learning to occur anytime, anyplace and to allow for greater customisation and flexibility of learning contents at the level of granularity desired.

In the EVLM database there are available several forms of reusable learning objects. Majority of the current study material is developed as educational text with illustrative figures and solved examples. These are stored as PDF, JSP, HTML or XML document files with embedded MathML coding of formulas and expressions. Presentation of these materials is possible in the most commonly used web-browsers, e.g. MS Internet Explorer or Mozilla Firefox, using the standard plug-in as Acrobat reader, Java Plug-in technology included as part of the Java Runtime Environment, Standard Edition (Java SE), which establishes a connection between popular browsers and the Java platform. This connection enables applets on Web sites to be run within a browser on the desktop.

Several examples of reusable learning objects that can be found in the EVLM Central database are illustrated in figures 2 - 5.

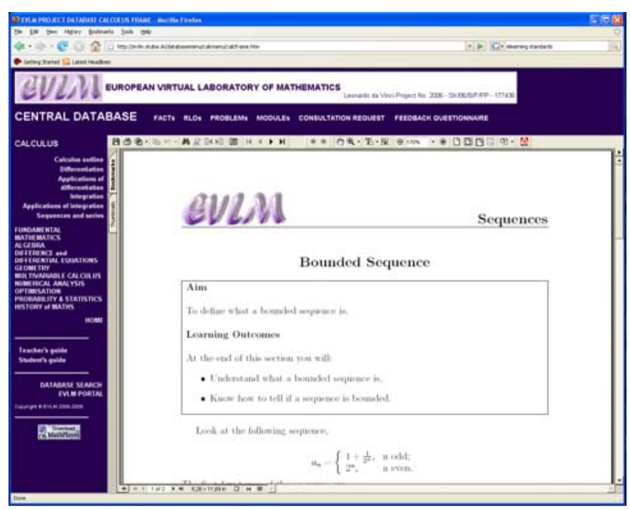

Fig. 2. RLO – Bounded Sequences, PDF file

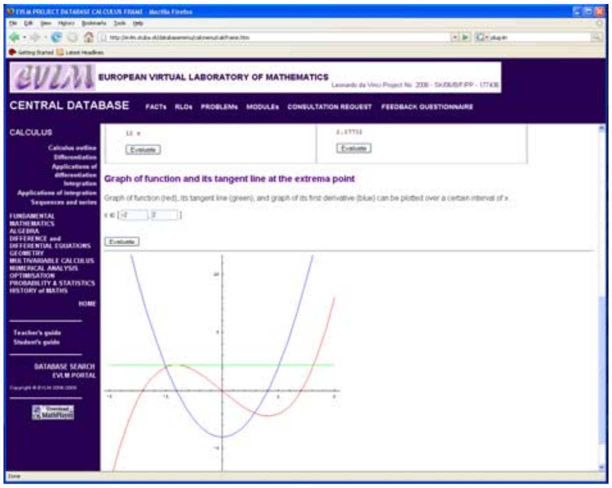

Fig. 3. RLO – Function Extrema, JSP file

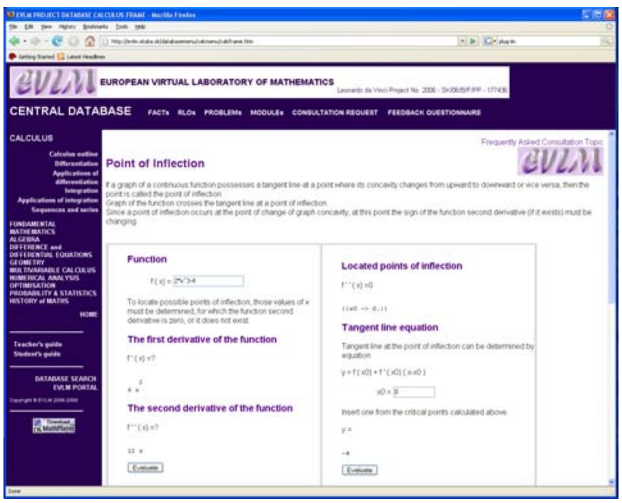

Fig. 4. RLO – Point of Inflection, JSP file

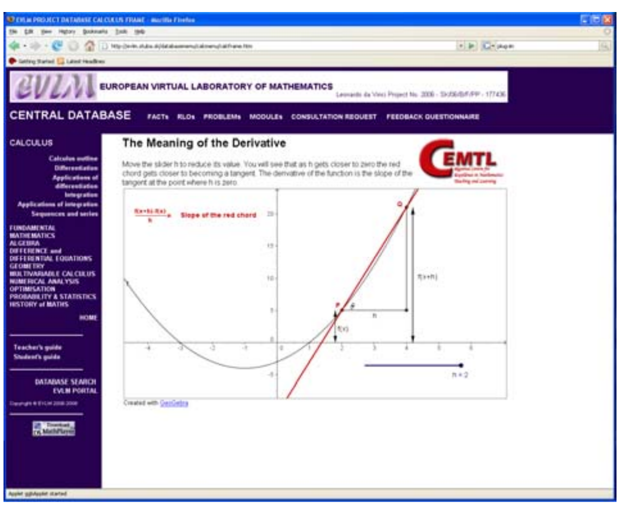

Fig. 5. RLO – the Meaning of the derivative, JSP file

The first presented example in Fig. 2. is PDF file, where prior to the instructional text there are presented the aim and learning outcomes. Two of the JSP files, which are webMathematica applets, are presented in Fig. 3. and in Fig. 4. Concepts of extrema points and point of inflection of function in one variable are explained and calculated by the system webMathematica engine for a particular function that can be inserted interactively, on-line. This way, students can practise mechanisms of identification of extrema points or points of inflection, and enhance the concept understanding by its geometric interpretation and representation provided in the plotted graph of the respective inserted function and tangent line to the function graph at the indicated point.

Concept of the function derivative and its geometric meaning is graphically illustrated in the last example presented in Fig. 5. Here the JSP file that was created by the GeoGebra free-ware software is illustrated. The presented file is Java applet, in which you can interactively create animation of the limit process hidden in the function derivative definition.

5. Conclusions

The use of learning object as a part of the design and development process of online learning settings provides a number of advantages. Until now, there has been relatively little activity undertaken to ensure that online learning settings are being designed in way that promote flexible use of the learning resources. This paper has discussed the use of learning objects with sound instructional design principles to define the object-based lesson model, and then highlighted the practical experiences of storing, using and assembling learning objects of particular interest is the RLOs from which multitude of different object-based lesson can be made.

E-learning technologies allow information to be presented in a more accessible, customized, learner-centred manner. Combining text, theory, and application with computer software, simulations, audio, video, and real-time discussion, all offered over the Internet, has made education more accessible than ever before. Students control the times and the pace of learning and determine the best method suited to their learning style. Teachers present the information, provide feedback, and serve in an advisory manner.

Research in cognitive psychology indicates that our brains store knowledge using both words and images. Instruction that targets and engages both of these systems of representation has been shown to significantly increase students' comprehension and retention. Explicitly engaging students in the creation and usage of non-linguistic representations has even been shown to stimulate and increase activity in the brain. Manipulatives are concrete or symbolic artefacts that students interact with while learning new topics. They are powerful instructional aids because they enable active, hands-on exploration of abstract concepts. Research has shown that computer-based manipulatives are even more effective than ones involving physical objects, in part because they can dynamically link multiple representations together.

A powerful XML-based mark-up language for publishing mathematics on the Web, MathML makes it possible to develop Web-based applications for displaying, searching, indexing, archiving, and evaluating mathematical content. MathML is about encoding the structure of mathematical expressions so that they can be displayed, manipulated and shared over the World Wide Web. A carefully encoded MathML expression can be evaluated in a computer algebra system, rendered in a Web browser, edited in the word processor, and printed on the laser printer. Mathematical software vendors are adding MathML support at a rapid pace, and MathML is fast becoming the lingua franca of scientific publication on the Web.

Consultation Centre of Mathematics working at the EVLM Slovak portal hosted by the Mechanical Engineering Faculty of the Slovak University of Technology in Bratislava, which was a part of the EVLM project, conveyed a thorough survey on usage of available e-learning materials in the Slovak EVLM Database accessible free on the address [10]. Students answered few questions on how did they use the instruction materials, what was the benefit for them and how they evaluate the service available. Results were rather surprising, but encouraging. Majority of students were satisfied and found it very convenient to access the necessary information directly from the internet, free of charge, in many forms and at any time. They highly appreciated different forms of e-learning materials, especially reusable learning objects – RLOs and short on-line java animations and on-line calculations - FACTs, as very compact, brief and instructive materials that helped them in learning progress. Anyhow, most of them preferred contact personal consultations with tutor, in order to achieve better comprehension and understanding of the mathematical topics.

The overall evaluation of the European Virtual Laboratory of Mathematics was very positive also in the European context, where all partner institutions from 7 European countries received feedback from users of their national EVLM Portals. These were often visited and materials in national languages were utilised on a large scale. Central portal with materials in English were used by less visitors, due to fact that almost all students prefer to read instructional material in national language, which was even more stressed in connection to different mathematical subjects and instruction materials related to mathematical topics and basic concepts.

At the end of this paper, it is quite relevant to mention one short citation from an interesting paper, which was written already in 2000 by Wayne Hodgins and Marcia Conner, *Everything you ever wanted to know about learning standards but were afraid to ask* [11], but which is still true.

"*While much of these information may seem at times like techno-mumbo-jumbo and engineering speak, like learning any new language or way of doing something, it will seem hard at first but one will learn it quickly. Better start now and lead the pack than miss this vibrant opportunity to change and improve how all of us work and learn each day.* "

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