

The use of digital learning objects for effective mathematics instruction

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Abstract

Digital learning objects (DLOs) can be defined as interactive (web-based) tools that are mainly used and reused for learning, education or training. In mathematics education, we use DLO for its potential to help students to understand phenomena, whose introduction in the traditional way of teaching mathematics could be problematic. We analysed one of the biggest and well known DLO repositories on the web RVP.cz, which is the main methodological support for teachers and implementation of the educational framework. We followed representation of the three DLO types of category 2 introduced in this text.

Keywords: Digital learning objects, DL, educational games, DLO repository, survey.

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1. Introduction

During the last decade, e-learning has become a widespread phenomenon. Nocar (2004) defines e-learning as a multimedia support of the educational process, connected with modern information and communication technologies to improve education. Or it may be defined as educational process which uses digital technologies (hardware, web, and specialised software) and digital entities (digital text, multimedia objects, etc.) to reach the set aims.

Current Czech tertiary education (mainly part-time and distance degree courses) widely uses e-learning. The popularity of e-learning is rising even at secondary schools, which is a very positive trend. We can also watch first attempts to apply e-learning at primary schools.

The more the e-learning education is applied, the more we need to respect certain standards, which can ascertain compatibility of individual learning objects (LOs) with e-learning platforms—systems for learning management systems (LMSs). It is important to know and respect the standard SCORM, because it is considered one of the most important and respected whole-world standards of e-learning education (Nocar, 2005a).

The standards are essential for transmission and display of created electronic study materials in different LMSs. Moreover, it saves money and time of the authors. We can exchange materials and/or sell them, but it is not necessary to create new materials for every LMS we use.

2. Digital learning object

E-learning study texts form several different digital entities. This text mainly focuses on digital LOs (DLOs). New Media Consortium defines DLO as a group of materials (texts, hypertexts, graphics, pictures, simulations, films, sounds, etc.) which is reasonably structured and is based on educational aims and objectives (Smith, 2004; Klement, 2012). It is multimedia content, educational content, educational software or software instruments used in computer supported education (Polsani, 2006).

DLO can be understood as a category of multimedia learning aids. Dostal (2009, p. 20) defines multimedia learning aid as ‘a digital tool integrating various forms of documents and data (e.g., texts, tables, animations, pictures, sounds, video, etc.), which present and copy the reality to help and simplify the education’.

A significant characteristic of DLO is their unrestricted accessibility anytime and their repeatable applicability. Digital character of the entities enables to spread them easily via Internet or Intranet, which means they are accessible to any user (depending on technological conditions) at the same time (Willey, 2015).

3. DLO—a learning aid

Elements, which try to visualise information, are implemented in study materials, because they help to understand and remember the information. Printed materials can be completed by static objects—pictures, concept maps, graphs. Electronic materials can contain dynamic objects—animations and audio or video sequences. It makes the material even more illustrative and gripping. Nevertheless, we need to consider when and how much to use these multimedia elements. These elements are very strong. Therefore, we have to use them cautiously because excessive use can have the opposite impact on learning process. Not all the materials have to be multimedia at the maximum (Nocar, 2004).

According to Smith (2004), DLO itself should form its own content and user interface. The content can be understood as texts, pictures, audio and video material. The interface is the part of DLO which helps a user to interact and operate the DLO. The interface forms graphical layout, control elements and other elements helping the user to operate the DLO. The interface can be very simple, where the

only interaction is to turn on or turn off, but it can also be very complicated containing several control elements (turn on, interrupt, change number or graphic parameters, etc.).

4. DLO suitable for teaching mathematics

1. **Animation**—animation of a particular phenomenon or a group of phenomena without the possibility to change the course of the animation by a user (except for turning it on and off, repeating it). Possible format: flash animation, video sequence and other video formats (*.avi, *.wma etc.).
2. **Interactive animation or simulation**—animation of a particular phenomenon or a group of phenomena with the possibility to change the course of the animation by a user. Dostal (2009) and Zilkova (in Pokorny & Malatinska, 2013) perceive the interactive character as immediate reciprocal communication (learner vs. multimedia learning aid, we can use the term DLO). The user interface enables students to change the course of the programme actively and dynamically. In an ideal situation, the DLO contains control elements or the user interface, which enables users to intentionally change the course of the animation. They are only limited by the design and conception of the DLO.
 - **DLO for a lecture**—*structured texts, decision trees or programmed LOs*—user environment enables a user to choose his/her own way of learning, gaining information or revealing terms of a theory. As an example, we can use a decision tree of determining the type of a combinatorial task.
 - **Interactive DLO**—Dynamic simulation—level of interactivity is much higher than in previous case. A user can change individual parameters of the simulation (e.g., it enables the user to change any coefficient in a square function, which influences the graph form). This way student can build their own knowledge within the meaning of constructive theories. Possible formats: flash animations, *.ppt, *.xls(x) etc.
 - **Dynamic simulation with feedback or/and self-evaluation**—simulation enabling to change parameters of a model is extended by feedback in the form of a test to check the understanding of the topic.

5. Educational games (Game-based learning)

Computers, information and communication technologies belong to everyday life of adults and children. The most commonly used computer programmes, children tend to use, are computer games and they are one of the favourite programmes that can be used in learning. (Bartek, Hotova & Zdrahal, 2008; Uhlířova, 2005). These applications often are educational games or educational programmes with 'entertainment' elements, which have a function of a reward for e.g., well calculated tasks. These programmes are called 'edutainment'.

Belohradská's (2006) repeated surveys, conducted among Czech pupils of primary schools, prove that playing computer games (non-didactic) is one of the most common free time activity among pupils. It takes the first place in the list of free time activities among boys (70–80%) in grades 5–9. This number remains stable. On the other hand, the number of girls playing computer games decreases with age. The fact that children use computers for work and study less often is very important as well.

We can include applications which do not have to contain math tasks (e.g., calculations and their checking in this category). They can improve thinking or user's skills in other areas of mathematics as e.g., combinatorial thinking, probability, logic and strategy. Calculations can form extension of the application, which can be conducted by different software.

6. DLO repository in the Czech Republic

Modern technologies make it easier to share digital content, which assures its availability and applicability. The individual categories and types of DLO available in Czech repositories can tell us more about their use at Czech schools.

There are a few repositories in the Czech Republic (Neumajer, 2008). We analysed one of the biggest and well known repositories on the web RVP.cz, which is the main methodological support for teachers and implementation of the educational framework. The DLO gathered here in years 2008–2014 was created by teachers for different levels of education and different disciplines within ESF projects and is called **digital learning material**.

Our survey is only focused on DLO for teaching mathematics at primary schools (from 5th to 9th grade). We followed representation of the three DLO types of category 2 introduced in this text. We analysed all 614 subjects and the results are as follows.

Table 1. Frequency DLO's and digital formats

	Digital format	<i>n</i>	Σ
DLO for a lecture	txt, odt, pdf	256	487
	ppt, odp	205	
	xls, ods	26	
Interactive DLO—dynamic simulation	ppt, odp	75	87
	xls, ods	9	
	other	3	
Dynamic simulation with feedback or/and self-evaluation	xls, ods	33	40
	ppt, odp	2	
	html, other	5	
Total		614	614

Complete results can be represented graphically as follows (Figure 1).

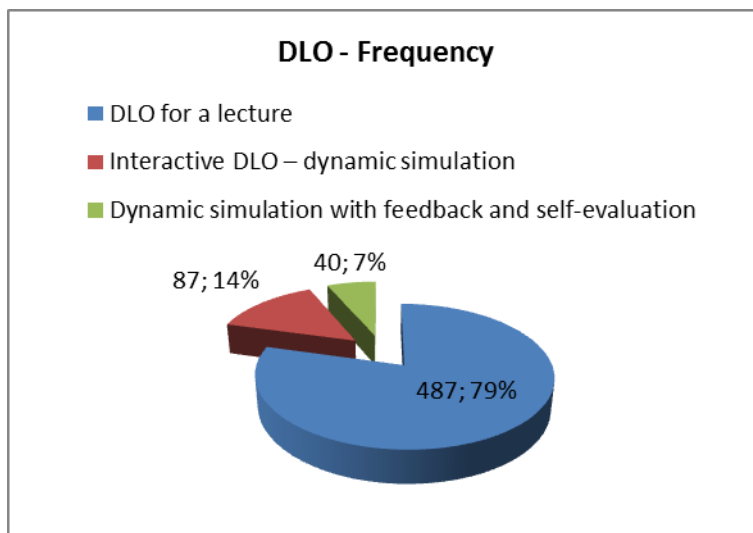


Figure 1. DLO frequency

The results prove that teachers, creating digital content of digital learning materials, mainly create non-interactive and less complex DLO, most of them can be used in non-electronic form—worksheets, games etc. We are positive about the number of interactive DLOs, which is quite high exceeding 21%.

These can be used only in connection with digital technologies—computers, interactive boards, tablets. This trend can be explained by worse availability of technologies at some schools recently. Secondly, it may be caused by the teachers’ insecurity in using the software. Flash elements were not noticed to be used at all.

DLO for a lecture—non-interactive DLOs (Figure 2) were usually in the form of texts, worksheets etc. Graph represents the gathered data. Some files were created in more data formats; therefore, we included only the first one listed.

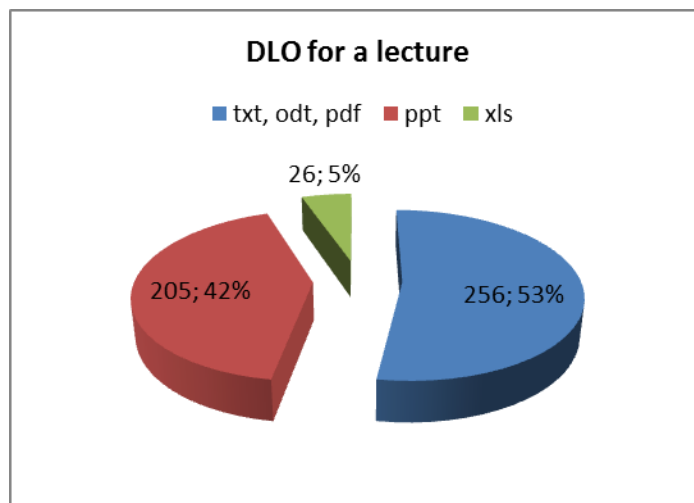


Figure 2. DLO for a lecture

Interactive DLOs (Figure 3) include objects which enabled at least elementary interactive control and the possibility of choice. The majority here was also represented by presentations; advanced table calculators and other digital formats represented 14% of the sample.

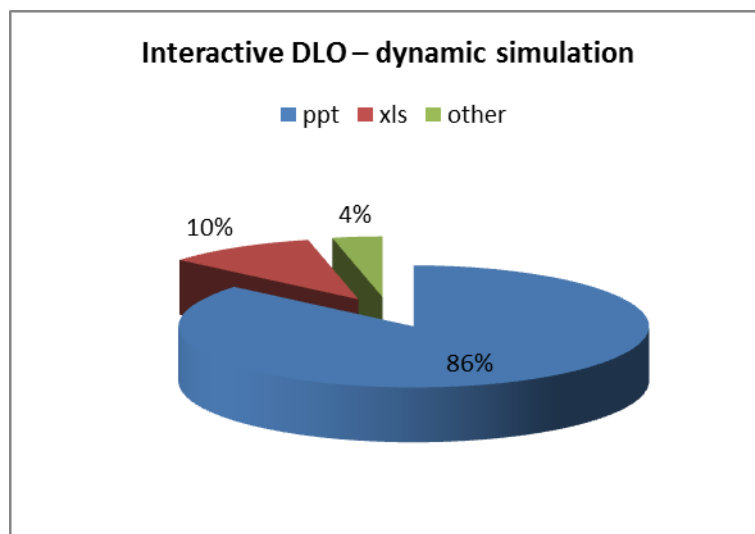


Figure 3. Interactive DLO—dynamic simulation

The last category followed in our survey is **Dynamic simulations with feedback or/and self-evaluation** (Figure 4). This category was surprisingly equally large as the previous two categories. It mainly included files created by table calculators. The authors can reach better interactivity and

feedback using these. We have also come across files created in different formats—e.g., created by programmes for dynamic geometry and exported in websites or JAVA applets.

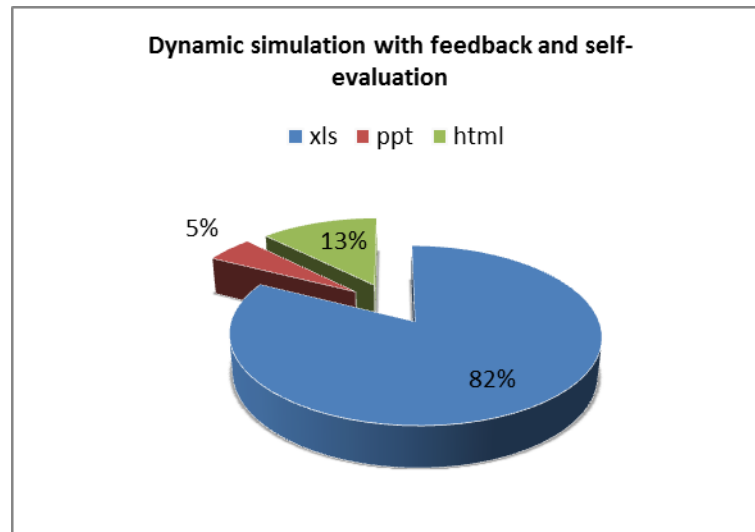


Figure 4. Dynamic simulation with feedback and self-evaluationti

7. Conclusion

We believe that our survey represents main characteristics of DLOs used in teaching mathematics in Czech primary schools. Unfortunately, it shows that majority of DLOs does not use the potential that digital technologies are offering. To increase the efficiency, the proportion of DLOs used in teaching mathematics should be opposite from what our survey shows. School mathematics offers so many topics for dynamic modelling and simulation.

DLO applications in teaching and learning at different levels of education system provokes a lot of questions, it enables us to formulate now hypothesis connected with their use in learning and their impact on educational process. DLO can be both an object of a survey and research tool.

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