A Systematic Review of Methods for Developing Open Educational Resources

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Abstract: Educational resources, such as learning objects, have been more and more used in education and training context. The free and open distribution of these resources contributes to the dissemination of knowledge and facilitates access to information. Following this trend, Open Educational Resources (OER's) have emerged to assist in the teaching and learning processes in general. Motivated by this scenario, the purpose of this paper is to characterize the state-of-the-art regarding the development, delivery and reuse of OER's. A systematic literature review was conducted and some initiatives were identified and investigated. Additionally, a preliminary set of characteristics to be considered in the development of OER's was also established. In general, we noticed a lack of systematic methods for the appropriate creation and adoption of OER's. In this sense, this work provides guidance for new research and development in the area.

Keywords: Open educational resources, development methods, systematic review.

Introduction

The advent of the Internet and advances in Information and Communication Technologies (ICT's) has changed the educational context, both in traditional as well as in blended and distance learning. As a result, there has been a change in the way that educational content is designed, developed and delivered to learners. Faced with these transformations, in recent years education and training issues have been attracting more and more interest from researchers around the world.

Learning objects (LO's) have emerged as interesting alternatives in this context. In short, a LO can be characterized as a reusable digital content used as educational support. The main idea is to allow the educational content be "broken into small pieces", which can be reused in different contexts and scenarios of education and training [33].

In many aspects of development, the production of LO's is similar to software development. In the case of software, methods, procedures and tools have been established aiming at contributing to the development of quality products [24]. Similarly, the use of appropriate mechanisms to ensure the productivity of the development process and the quality of the resultant products are also critical with respect to LO's.

Agile methods [10] fit in this context, addressing a new approach to development, focusing on agility, flexibility, skills to communication and the ability to deliver new product and services with added values to the market and in defined time [2],[3].

In a different but related perspective, the advent of Free Libre and Open Source Software (FLOSS) [15] has also motivated research and development in the education area. In 1998, Wiley [33] introduced the concept of "open content" to refer to all content available to its users in an open way, creating the Open Content License and later the

Open Publication License for the publication of these contents. The idea was to encourage debate and the availability of open educational content by institutions of higher education.

Recently, there arose the term *Open Educational Resources* (OER's) in an attempt to standardize the educational content available in a free and open way through the Internet. The OER's are characterized as digital materials available in a free and open way to the general community, with the purpose of teaching, learning and research. Basically, an OER encompasses: (1) *learning resources*, such as LO's, full courses and educational modules; (2) *tools*, such as supporting systems to the development, (re)use and delivery of learning content; and (3) *implementation resources*, such as intellectual property licenses to promote the publication, reuse and dissemination of the educational content [16].

Motivated by this scenario, this paper aims at characterizing the state-of-the-art of methods for developing OER's. A systematic review was conducted and, in order to compare and evaluate the studies found through this process, a set of characteristics for the development of OER's was proposed. The results presented herein will underlie the establishment of systematic methods for the development of quality and reliable OER's.

The remainder of this paper is organized as follows. Section 1 outlines the systematic review planning, defining the review protocol for the study; the review execution is also described. The results obtained are presented and analyzed in Section 2. Finally, in Section 3, our conclusions and perspectives for further work are summarized.

1. Systematic Review Planning and Execution

A Systematic Literature Review can be seen as the process of identification, evaluation, and interpretation of available and relevant researches for a research question, thematic area or interest phenomenon. The aim is to provide a fair assessment (not biased) for a research topic, by an auditable, reliable and accurate approach [21].

The systematic review process begins with the planning phase through a pre-defined review protocol, which includes: (1) the research objectives; (2) the research questions to be answered; (3) the search strategy for conducting the review; and (4) the criteria and procedures for the studies selection.

1.1 Research Objectives

Our systematic review aimed at characterizing the methods that support the learning objects development, focusing on OER's. Additionally, agile methods were also considered. To clarify, the objectives were subdivided into: (1) investigate and analyze methods that support the development of LO's; (2) investigate and analyze the applicability of agile methods in the development of LO's; and (3) investigate and analyze methods that support the development and delivery of OER's.

1.2 Research Questions

From the aforementioned objectives, the following research questions were defined: (1) *Primary question*: Which methods have been used in the development of LO's? (2) *Secondary questions*: Which methods are specifically related to agile methods? and which methods are specifically related to the development and delivery of OER's?

The research questions were grounded in different perspectives, being included within the following scope and specificities: (1) *intervention*: development of OER's; (2) *population*: researches that cover the development of LO's (and OER's); and (3) *results*: methods to support the development of LO's, especially OER's.

1.3 Search Strategy

The search strategy consists in defining: (1) the search sources for selecting the studies; (2) the language of the studies; and (3) the terms and synonyms for constructing the search string. The sources were selected taking into account criteria such as: the importance and relevance of search sources, the availability of search query through the web, the number of indexed researches, and the reliability of results. The selected sources are shown in Table 1, including electronic and manual databases (conference proceedings, periodicals, technical reports, etc.) as well as consulting specialists and researchers related to the area.

Table 1: Search sources

Source	**Location**
ACM Digital Library	http://portal.acm.org/dl.cfm
IEEE Xplore Digital Library	http://ieeexplore.ieee.org
Scopus	http://www.scopus.com
Web of Knowledge (Web of Science)	http://apps.webofknowledge.com
CBIE – Brazilian Congress on Computer Science Education	http://www.sbie.org.br
RBIE – Journal of Computing in Education	http://www.rbie.org.br

A general search string was built from the combination of terms and synonyms associated to educational resources in general, using boolean operators (AND/OR). When necessary, the search string was analyzed and refined according to the needs and characteristics of each database. This procedure was aimed at evaluating the relevance of the terms used and the relevance of the studies returned.

1.4 Studies Selection

Inclusion and exclusion criteria had also to be explicitly defined in order to return coherent and consistent results for the research. Inclusion criteria were: (1) *Primary Question*: studies describing methods to support the development of LO's. (2) *Secondary Questions*: (2a) studies applying agile methods in the development of LO's; and (2b) studies addressing the development and delivery of OER's.

Exclusion criteria were: (1) *Primary Question*: studies describing approaches applied in other areas. (2) *Secondary Questions*: (2a) studies applying agile methods in other contexts; (2b) studies addressing open content outside the educational context; and (2c) studies that were not fully available for reading.

The studies selection was performed in two phases. In first phase, *preliminary selection*, the emphasis was on reading the abstracts of the studies returned by the search string. In the second phase, *final selection*, the studies were read in full by the reviewer.

The systematic review was conducted during February – April/2012. While executing the searches, the results were documented for further analysis. All the data extracted was summarized and documented. To facilitate the management of the references, we used the JabRef tool [20]; the tool supports the prioritization of the readings, the retrieval of studies for reading, and the identification of duplicate studies. We also used ReVis [31], a supporting tool for the visual exploration of the studies collected.

2. Results and Discussion

The number of the studies selected in each search source, both in the preliminary and in the final phases, is shown in Table 3. The systematic review returned 240 papers,

discarding duplicated studies. In the preliminary stage, 45 papers were pre-selected for full reading. In the end, 14 papers were considered relevant to the aims of the review.

Table 2. Studies selected in each database

Database	Result	Preliminary Selection		Final Selection	
		Included	Excluded	Included	Excluded
ACM Digital Library	45	8	37	2	6
IEEE Xplorer Digital Library	64	12	52	6	6
Scopus	78	10	68	1	9
Web of Knowledge (Web of Science)	46	10	36	1	9
CBIE and RBIE	4	3	1	2	1
Specialists	3	2	1	2	-
Total	240	45	195	14	31

Figure 1 illustrates the bi-dimensional maps of the studies collected, constructed from the ReVis tool [31]. The bi-dimensional maps distribute the studies collected over the window space, grouping the most similar studies and isolating the most distinguished. This distribution is made according to the contents of the study, i.e., a combination of titles, keywords and abstracts. Figure 1(a) shows the studies selected in the preliminary phase, represented by small circles colored in green; the red circles represent the studies that were excluded. Figure 1(b) highlights the studies selected in the final phase.

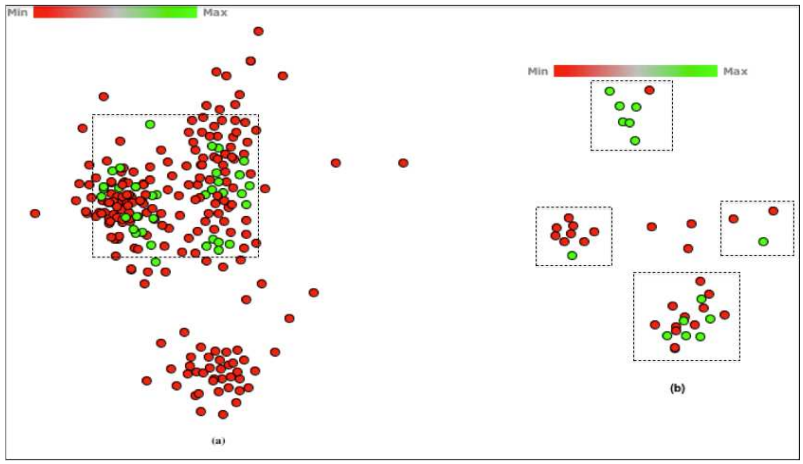

Figure 1. Visual maps of collected studies

A synthesis of the selected studies, along with the inclusion criteria used, is presented in Table 4.

In order to compare and evaluate the studies found through the systematic review, we have also defined a preliminary set of characteristics considered relevant from the perspective of the development of OER's (Table 5).

The results obtained with the evaluation of the studies are summarized in Table 6. From the perspective of methodology (foundation), Boyle et al. [13] propose a method for the development of LO's based on agile practices, aiming at providing a robust and flexible structure that contributes to the creation of quality educational content. Lapolli et. al. [23] propose a model of instructional design for LO's grounded in assumptions of agile methods, specifically in the technique of Behavior-Driven Development (BDD) [9] and in eXtreme Programming (XP).

Barbosa and Maldonado [6] have proposed a Standard Process for Developing Educational Modules (SP-DEM) based on the ISO/IEC 12207 standard [19] and on the ADDIE model [32]. The SP-DEM aims at establishing guidelines for development and

systematic evolution of educational modules. Patricia et. al. [28] also uses the ADDIE model as the basis for a life cycle for OER's; activities to incorporate social networking and semantic technologies were also considered. Finally, Oliveira et al. [27] have proposed a life cycle for the elaboration of LO's based on the spiral model [30] of software development.

Table 4. Focus of selected studies

Author	Main Goal
[4]	Proposition of a process model for Web-based educational modules.
[22]	Development of a LO for teaching network technologies. Design and development principles of the LO are discussed.
[6]	Proposition of a standard process for the elaboration of educational modules based on ISO / IEC 12207.
[5]	Development of an educational module for teaching mutation testing according to a content modeling approach.
[27]	Proposition of a life cycle for the elaboration of LO's based in the spiral model.
[7]	Development of an education module for teaching inspection and testing techniques.
[8]	Development of an educational module for teaching fundamentals of programming and testing. Proposition of an automated tool for evaluating programming assignments based on testing activities.
[29]	Proposition of a process for the development of LO's.
[11]	Elaboration of LO for Learning Virtual Community (COMVIA).
[13]	Proposition of a method for developing LO's based on agile methods.
[23]	Proposition of an instructional model of LO's based on interaction design and agile practices.
[28]	Proposition of a life cycle for OER's based on social tools and web semantics.
[14]	Proposition of a model of LO's for online learning based in the European Higher Education Area (LOMOLEHEA).
[12]	Proposition of a supporting tool for modeling educational content.

Table 5: Set of characteristic

Characteristic	Description
Methodology	To ensure that OER's effectively contribute to the teaching and learning process, it is necessary to use appropriate approaches and methodologies that support design and developmental tasks and activities.
Standards	The use of standards for metadata (such as Learning Object Metadata (LOM) [17] and for packaging (such IMS Content Packaging [18]) ensures the availability of OER's in different Learning Repositories (LR). Besides that, standards facilitate the search, retrieval and reuse of the educational content.
Learning repositories	OER's should be available through LCMS or LR in order to provide reuse.
Collaborative and distributed development	The elaboration of OER's may involve developers from diverse areas of knowledge, working in multidisciplinary teams and heterogeneous, geographically dispersed or not. In this case, it is necessary to consider aspects of collaborative and distributed development as the systematic monitoring of activities and modules that compose the resources, and the support for communication among the teams.
Web 2.0 and semantic web technologies	The integration of social tools encourages the active participation of developers and users in the construction of OER's, being also important in distributed and collaborative development of such resources. Moreover, semantic web technology improves searches of educational resources by using their semantic meaning.
Environments and tools	The use of environments and tools to support the construction of OER's tend to facilitate the development tasks, besides contributing to the quality of the final product.
Licenses	To preserve the authorship rights and intellectual properties, the free and open distribution of an educational resource must take place under the appropriate license.

The IMA-CID approach (Integrated Modeling Approach – Conceptual, Instructional and Didactic) is used as a basis for developing educational resources in [5], [8] and [12]. Furthermore, in [7] and [8] the authors also use the SP-DEM process.

Table 6. Comparison of the methods considered

Author	*Methodology (Foundation)*	*Standard*		*LR*	*Collaborative /Distributed Development*	*Web 2.0 and Semantic Web*	*Environment and Supporting Tool*	*License*
		Metadata	*Packaging*					
[27]	Spiral Model	LOM	SCORM					
[29]		LOM	SCORM					
[6]	ISO/IEC 12207, ADDIE Model	LOM						CCL
[13]	Agile Methods	LOM/IMS Metadata		√	√			
[23]	Agile Methods		SCORM					
[28]	ADDIE Model	LOM/IMS Metadata	SCORM	√		√		CCL
[10]				√	√			
[14]		LOM	SCORM					
[22]					√			
[4]								
[5]	IMA-CID	LOM						
[7]	SP-DEM	LOM						
[8]	SP-DEM, IMA-CID	LOM						
[12]	IMA-CID	LOM						

The other studies ([4], [10], [14], [29]) did not specify any method for the development of educational resources.

Considering the use of standards, most of the studies adopted LOM for metadata and SCORM for content packaging and associated metadata. On the other hand, [4] and [22] did not use any standard for metadata and packaging, while [5], [6], [7], [8] and [12] did not adopt any standard only for content packaging.

Regarding learning repositories (LR), in general they are rarely explored by in the storage and retrieval of educational resources, which hinders the dissemination and reuse of such resources. Among the methods found, only a few ([10], [13], [28], [29]) addresses educational resources for institutionalized repositories. Likewise, aspects related to the collaborative and distributed development are almost unexplored, being investigated only by [6] [10], [13], [22]. In the case of OER's, the use of collaborative technologies (such as e-mail, mailing lists, web, social tools, versions control systems, information repositories, etc.) is essential not only in the development process, but also during the delivery and use of the content itself in order to facilitate the conducting the activities and assessments proposed to learners.

Little attention was also given to the adoption of emerging technologies, such as Web 2.0 and semantic web. Despite the great potential to effectively contribute to the development, delivery and search of OER's, such technologies were considered only in the method proposed by Patricia et al. [28].

Another limitation observed refers to the lack of licenses to establish the authoring rights and intellectual properties on the content developed as well as the details for its use, modification and distribution. Only the methods proposed by [5] and [6] specify the use of licenses; in both cases, the Creative Commons License (CCL).

Finally (and interestingly), none of the methods analyzed specify the adoption of computational tools and environments in order to support the automation of the activities and tasks associated.

4. Conclusions and Further Work

In this paper we presented a systematic literature review aiming at identifying the state-of-the-art regarding the development, delivery and reuse of open educational resources. Additionally to the review conducted, we also highlight as a contribution of this paper the establishment of a set of characteristics to be considered in the development of OER's.

In general, we have identified different methods being used, ranging from the modeling phase and instructional design to the development of associated educational content. However, despite OER's have emerged as a viable technology to the social-economic development, we highlight the lack of systematic methods for their appropriate creation and adoption. In this sense, this work intends to provide guidance for new research and development in the area.

The limitations and weaknesses observed motivate the study and proposition of systematic methods for the development, delivery and reuse of flexible, quality and reliable OER's. Characteristics such as openness, collaboration, cooperation and distribution should also be considered in this perspective. At the same time, there is a need for the establishment and adoption of automated tools and environments to support the related activities.

As further work, based on the results obtained, we intend to work on the establishment of systematic methods for developing and providing quality educational resources, capable of motivating learners and contributing to their process of knowledge construction. Aspects related to the establishment of supporting environments for the OER's creation must also be defined and incorporated into the proposed method. Among the expected results, we emphasize the development of a pilot environment for the construction, storage and retrieval of open educational resources its validation in the creation of OER's for different knowledge areas.

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