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Open Educational Resources for Software Engineering: an Overview

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ABSTRACT
Open Educational Resources (OERs) are one of the main pillars of the digital education era. Currently, they are mainly spread through open repositories and universities. In this study, we provide an overview on how the open access repositories and world top universities are producing and delivering OERs for the Software Engineering (SE) area. Our goal is to gather the main characteristics of the available SE OERs in the repositories and to rank the effort of the universities to the open access movement, particularly in the SE courses. Our findings showed that, despite some good initiatives have been identified, most of the SE sub-areas have not been well-covered in terms of OERs in the existing repositories. Furthermore, considering the academic setting, the majority of the universities have still not been able to successfully share the SE knowledge to the public in general.

Author Keywords
Open Educational Resources; Software Engineering; Open Repositories; Universities.

CCS Concepts
•**Applied computing** → **Digital libraries and archives;**

INTRODUCTION
Education has been changing through the years, particularly with the support of the Internet and the advances in Information and Communication Technologies (ICTs). Researchers around the world have paid more attention to teaching, learning and training issues in an attempt to transform the way educational content is designed, developed and delivered to learners. As a result, initiatives such as Learning Objects (LOs) and Open Educational Resources (OERs) have been playing a more and more significant role [2].

According to Wiley [1], a LO corresponds to "any digital resource that can be reused to support learning". In another well accepted definition, IEEE [11] stated that "any entity, digital or non digital that can be used for learning, teaching or training can be treated as a LO". For the purposes of this work, a LO will be treated as digital media (e.g., videos, images, pdf texts) used for the purpose of teaching or learning.

In a similar research line of LOs, Open Educational Resources (OERs) have emerged. According to William and Floret Hewlett [10], an OER can be seen as any LO that resides in public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions.

An important mechanism to share OERs is through open access repositories. In short, such repositories are digital platforms designed to provide free, permanent and immediate access to OERs, for anyone to download or distribute [13]. According to Wani [27], open access repositories have set new standards for information sharing and management. They are growing in quantity and diversity, being a significant research trend in OERs.

Universities, in turn, also play a significant role in the new era of digital learning. Gourley and Lane [9] claim that should be a goal to every university to made the world of knowledge a lot more democratic and open, bringing education to all that can be benefit by it. Nevertheless, one of the main inhibitors of the OERs growth is the lack of institutional policies and incentives for educators to produce and effectively adopt such resources [29].

In a different but related perspective, education in Software Engineering (SE) has played a more and more important role in the modern society, since there is an increasing need of well-prepared SE professionals, capable of designing quality software to almost all sectors of the society. Software Engineering is pervasive; innovations such as cloud computing, autonomous vehicles, drones, bioengineering, and other initiatives have made for a rapidly changing landscape. Topics such as software assurance, safety, and reliability have become increasingly important knowledge areas.

To keep up with these trending topics, educators need to identify suitable software engineering techniques, incorporating them into their class offerings. This gap establishes an interesting opportunity in which OERs are a key factor in the modernization process of education in Software Engineering.

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Provide open learning content can not only improve the education practices in general, but also the research in SE area in particular.

Motivated by this scenario, in this paper we aim at gathering information on how much effort the universities have spent in the development and effective delivery of OERs, especially in SE area. We also include open repositories in our investigation, since they can bring some answers of how these institutions can improve their digital libraries. Therefore, we highlight as the main goals of this work:

- To provide an evaluation of how the top Universities in Computer Science around the world, particularly in Latin America and in Brazil, are sharing their Software Engineering knowledge through OERs. The aim is to identify the main issues and help to improve the SE community in effectively adopting OERs.

- To gather information on the OERs of Software Engineering found in the current available open repositories. We intend to provide an overview of the existing OERs in the Software Engineering area. Based on the OERs retrieved, we will be able to build a general analysis of the current state of the SE discipline in the existing OERs repositories.

The remainder of this paper is organized as follows. Section 2 summarizes the related work. Section 3 provides an overview of OERs for Software Engineering in the academic setting. Section 4 also provides an overview of LOs and OERs for Software Engineering, but now retrieved from open access repositories. Finally, conclusions and future work are discussed in Section 5.

RELATED WORK

In this section we present some studies related to our work. In general, the current research mainly focuses on how to evaluate LOs and OERs; many authors proposed evaluation methods, but using different approaches and for different purposes. Also, there are some researches concerned in showing the open repositories and how to integrate their content.

Villavicencio et al. [26] performed an evaluation of OERs for Software Engineering. Their main goal was to find out high quality learning material to be used in their own Software Engineering undergraduate courses. Through this research, the authors proposed an evaluation criterion for OERs, which could be used in any resource of any discipline. As a result, they were able to retrieve good quality OERs in Software Engineering, concluding that a teacher using the proposed criterion could optimize his/her time, increasing his/her focus on other didactic activities.

Kurilovas and Dagiene [15] analyzed some of the evaluation criteria for LOs available in the academic community (LORI, MELT and Q4R). Based on the limitations found, the authors proposed a more complex and robust technical evaluation method, which could better evaluate the LOs based on their life cycle stages and properly examine their reusability properties. Still according to the authors, the method proposed could better fit in virtual learning environments.

In Pavani's work [20], the offering of LOs in the Internet was investigated. The author looked into institutional repositories, union repositories and other websites that could provide learning objects. Using this process, an overview of LOs repositories and the availability of LOs in control systems was built. In the author's results, some of the most used open repositories available in the Internet were displayed and described. The author also stated the requirements for building a catalog system of LO, that could gather all LO available in the open repositories mentioned.

SOFTWARE ENGINEERING OERS IN UNIVERSITIES

We have investigated the development and adoption of Software Engineering OERs in universities around the world, especially in Latin America and Brazil.

In order to build this evaluation, the following steps were performed. At first, we settled which universities would be looked into. Then, we established an evaluation metric, with the purpose to rank the most committed institutions in terms of the development and adoption of Software Engineering OERs. Finally, the evaluation process was conducted and the main results were analyzed.

Choosing the Universities

Initially, it was necessary to set which universities, in Computer Science area, would be looked into. Our choice was based on the Top Universities ranking [24] for the best 5 universities globally (Table 1), and the best 5 universities in Latin America (Table 2). We also considered the best 25 universities in Brazil (Table 3), which were chosen based on RUF 2014 ranking [7].

Table 1. Top 5 World Universities

University	Country
Stanford	United States
MIT	United States
NTU	Singapore
ETH	Switzerland
Cambridge	England

Table 2. Top 5 Latin America (non-Brazilian) Universities

University	Country
IPN	Mexico
UNAM	Mexico
UC	Chile
ITESM	Mexico
Universidad de Chile	Chile

Evaluation Metrics

The OERs offerings in universities were measured according to three items, each one having scores between 1 and 5. The lowest total record possible was 3 and the highest one was 15. Each evaluation criteria is explained next.

[C1] Difficulty in finding OERs (1-5): how much effort would be necessary for a regular student to find an OER, starting from the institution main website.

Table 3. Top 25 Brazilian Universities

University Name	Acronym
Universidade de São Paulo	USP
Universidade Federal de Minas Gerais	UFMG
Universidade Federal do Rio de Janeiro	UFRJ
Universidade Federal do Rio Grande do Sul	UFRGS
Universidade Estadual de Campinas	UNICAMP
Universidade Estadual Paulista Júlio de Mesquita Filho	UNESP
Universidade Federal de Santa Catarina	UFSC
Universidade de Brasília	UNB
Universidade Federal do Paraná	UFPR
Universidade Federal de São Carlos	UFSCAR
Universidade Federal de Pernambuco	UFPE
Universidade Federal de São Paulo	UNIFESP
Universidade Federal do Ceará	UFC
Universidade Federal da Bahia	UFBA
Universidade Federal de Santa Maria	UFSM
Universidade Federal Fluminense	UFF
Universidade do Estado do Rio de Janeiro	UERJ
Pontificia Universidade Católica do Rio Grande do Sul	PUCRS
Universidade Federal de Visçosa	UFV
Pontificia Universidade Católica do Rio de Janeiro	PUCRIO
Universidade Federal do Rio Grande do Norte	UFRN
Universidade Federal de Goias	UFG
Universidade Estadual de Maringá	UEM
Universidade Estadual de Londrina	UEL
Universidade Federal da Paraíba	UFPB

1	No OERs were found in the institution website
2	OERs were found under great difficulty (subsections, laboratory pages, almost imperceptible links)
3	OERs were found under some difficulty (undergraduate pages, diminished links)
4	OERs were found under little difficulty (institute pages, highlighted links)
5	OERs were found under no difficulty (university main page, flashy links under huge text areas)

[C2] Amount of OERs retrieved (1-5): how many OERs were found in the university open database (considering the Software Engineering context).

1	No OERs were found in the institution website (N = 0)
2	Less than 5 items (N < 5)
3	Between 5 and 19 items (5 <= N <= 19)
4	Between 20 and 50 items (20 <= N <= 50)
5	More than 50 items (N > 50)

[C3] Diversity found in the OERs (1-5): how different the found resources are when compared its SE sub areas, media type and interactivity type.

1	No OERs were found in the institution website
2	Covers only one keyword, are displayed only in one media type and have only one interactivity type
3	Covers only two or three keywords, are displayed in one or more media types and have one or more interactivity types
4	Covers up to six keywords, are displayed in two or more media types and have at least two interactivity types
5	Covers up seven or more keywords, are displayed in three or more media types and have all three interactivity types

Searching Process

The searching process of OERs in each university previously selected was performed according to the following hierarchy of webpages:

1. University main page
2. Computer Science institute page
3. Computer Science undergraduate course page
4. Software Engineering laboratory page

If the web page had a search bar, a list of keywords would be written and searched. The list of keywords used is shown in Table 4. If no search bar was found, the keyboard search command would be used otherwise. If no results were found in these searches, the same process should be repeated in a lower level page. If no results were found at all, the University should receive the minimum total score of 3 points.

Table 4. Keywords used for each language

Language	Keywords
English	Open Educational Resources; Learning Object; Courseware; Software
Portuguese	Recurso Educacional Aberto; Objeto de Aprendizagem; Material Didático; Engenharia de Software
Spanish	Recurso Educativo Abierto; Objeto de Aprendizaje; Material Didáctico; Ingeniería de Software

Results

Among all universities considered in our research, only five of them had a total score higher than the minimum (3 points). The results are illustrated in Table 5.

Table 5. Universities with SE OERs

University	C1	C2	C3	Total
MIT	5	5	5	15
ETH	3	4	3	10
Cambridge	2	3	3	8
USP	2	2	2	6
UNAM	2	2	2	6

No Software Engineering OERs were found in any of the other 30 universities considered in our study. Because of this, such universities scored a total of only three points each. It is important to notice, however, that in UFMG, UNESP, UNB, Stanford, Pontifícia Universidad Católica de Chile and Universidad de Chile, the search successfully retrieved OERs of others disciplines and knowledge areas.

A great example of university promoting the open learning initiative is the Massachusetts Institute of Technology (MIT), with the MIT Open Courseware. It is a program, launched in 2002 with the support of William and Floret Hewlett foundation and Andrew W. Mellon Foundation, that provides a great number of OERs for undergraduate and graduate students [19]. Such content is originated from the previous year classes, including lectures, exercises, exams, among other learning resources. Everything is free, open and reachable.

Considering Software Engineering materials, in particular, the institution also shares whole SE courses from previous years classes. Lecture notes, exams, readings, exercises, among other different types of OERs were open and fully available for the public. In Figure 1, we provide an example of a lecture note from a Software Engineering class (Safety-Driven Design Process).

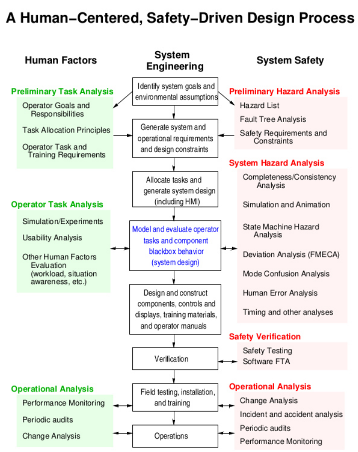

Figure 1. MIT Open Courseware lecture note

In a lesser extent, the University of Cambridge also share a previous year class lecture notes. This content was found at their Computer Laboratory web page, and covers some points of the SE spectrum, but with less materials and content deepness than MIT Open Courseware project.

In the University of São Paulo, the OERs were found at the SE research group web page [16] (LabES - *Laboratório de Engenharia de Software*). Their content is mainly lying in the Software Testing sub area, and is composed by didactic notes. Although the OERs cover a great part of Software Testing content, there aren't much objects and they aren't diverse, based on our evaluation metrics criteria.

The National Autonomous University of Mexico presents a similar scenario. Their content was retrieved through search bars results in theirs Media Campus web page [23]. They are mostly represented by recorded video lectures about general concepts of SE applied in a database context. Their score represents the limited amount of OERs and the lack of diversity of the approached themes.

The results of ETH Zurich were collected from the web page of the Department of Computer Science. They cover all the sub areas presented in a common SE course, but exclusively using lecture notes, which justifies their lack of better results in C3. A example of a retrieved lecture note is shown in Figure 2.

Although these universities (Table 5) stand out when compared to the whole set of universities considered in our research, they still presented important limitations. The most common issue is the difficulty to find access to the educational resources. In most of the cases, the student must click in many other

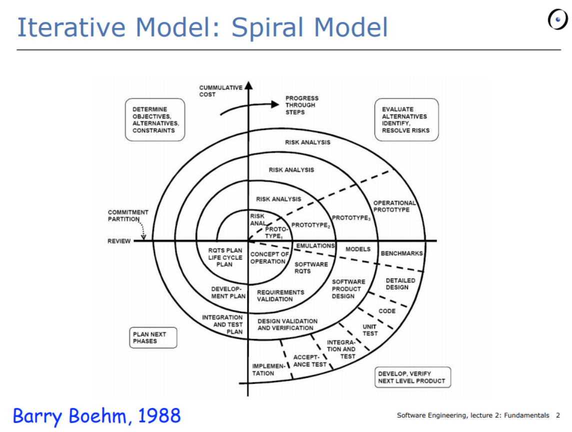

Figure 2. ETH Zurich lecture note

links until be able to find the content that he/she is looking for. Another problem is the lack of effort in sharing content of more SE sub areas, mostly submissions are being done to help one specific area and being careless about the other ones. At last, another issue is the lack of uniformity among the OERs. Actually, the institutions have not investing on the development of different didactic approaches in theirs OERs, but only submitting recycled lecture notes or recorded classes.

LOS AND OERS FOR SOFTWARE ENGINEERING IN OPEN ACCESS REPOSITORIES

In order to provide an overview of LOs and OERs in open access repositories, some steps were established and followed. At first, we settled which metadata structure would be used, crossing information among the most common Learning Object Metadata (LOM) standards and some studies in the area. Then, the keywords responsible for representing the Software Engineering body of knowledge were chosen. Finally, the searching process was designed and performed.

It is important to notice that, although the focus of our work be on OERs, some of the investigated repositories allocate their content as LOs. Therefore, we decided to also look for LOs, but distinguishing which of them had open licenses or not.

Establishing the Metadata Structure

"Metadata contains the data about the data and can be used to locate and manage the data" [14]. Metadata structure is the group of attributes that characterize the LO retrieved. These attributes define the relevant information that will be gathered and analyzed, resulting in an overview of how the LO is being offered and developed.

There are several LOM standards available for the learning community. Some examples are the UK Learning Object Metadata Core [22], IMS Content Packaging [18], Shareable Courseware Object Reference Model SCORM [21] and Dublin Core [6]. Due to its broad acceptance and adoption, in this work we chose the IEEE-LOM [11] as the main basis for our metadata structure model. The IEEE-LOM is a metadata standard developed in 2002 by the IEEE working group, being internationally recognized [3]. The standard is represented in nine categories, as shown in Figure 3.

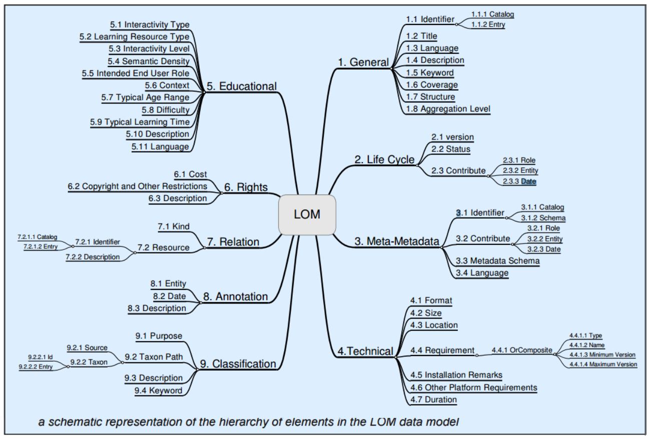

Figure 3. The IEEE-LOM Model [11]

Still considering the perspective of Learning Object Metadata, Ferlin et al. [8] compared the most popular metadata structures in order to find the most common attributes among them. Thus, they proposed a process to retrieve the essential attributes for characterizing the learning objects. As a result, they pointed out as essential attributes: Object ID, Title, Language, Description, Author, Date, Format, Size, Learning Resource Type, and Rights.

Based on the definitions of IEEE-LOM model [11] and on the essential attributes from Ferlin's study, we have established the LOM structure to be used in our research (Figure 4). We considered 15 attributes, divided in four categories, as specified in Table 6 and in Figure 4. Ferlin's attributes *Size* and *Date* were not considered due to the lack of information in the searched repositories.

Choosing the Keywords

In order to specify which keywords would be used in the searching process, the Software Engineering Body of Knowledge (SWEBOK) [12] was considered. The chosen keywords represent the majority of the content required in the discipline of Software Engineering. They are summarized in Table 7, with some of their associate content.

At last, the keyword "Software Engineering" was used to categorize learning objects which had the full Software Engineering course in their contents.

Searching the Open Repositories

The searching into the repositories was performed in three steps:

1. Use the search bar in order to find the learning objects related to a keyword.
2. Considering the results returned, if the title of an object matches the content of the keywords, inspect the link to that object. If none, return to step 1.

Table 6. Attributes Specification

ID	Name	Description
1	General	This category groups the general information that describes this learning object as a whole.
1.1	Object ID	A globally unique label that identifies this learning object.
1.2	Title	Name given to this learning object.
1.3	Repository	The name of the repository where the object is allocated.
1.4	Language	The primary human language(s) used within this learning object to communicate to the intended user.
1.5	Keyword	A keyword or phrase describing the topic of this learning object.
1.6	Description	A textual description of the content of this learning object.
1.7	Author	Those entities (people, organizations) that have contributed to the state of this learning object during its life cycle (creation, edits, publication).
2	Technical	This category describes the technical requirements and characteristics of this learning object.
2.1	Format	Technical datatype(s) of this learning object. This data element shall be used to identify the software needed to access the learning object.
2.2	Location	A string that is used to access this learning object, a URL (Universal Resource Identifier).
3	Educational	This category describes the key educational or pedagogic characteristics of this learning object.
3.1	Interactivity Type	Predominant mode of learning supported by this learning project (active, expositive or mixed).
3.2	Learning Resource Type	Specific kind of learning object. Examples: exercise, simulation, graphic, presentation, book, table, test.
3.3	Intended End User Role	Principal user(s) for which this learning object was designed, most dominant first.
4	Rights	This category describes the intellectual property rights and conditions of use for this learning object.
4.1	Cost	Whether use of this learning object requires payment.
4.2	Creative Commons	Which Creative Commons license are applied to the use of this learning object.
4.3	Copyright	Whether copyright apply to the use of this learning object.

3. If the link to the object is available, its information should be extracted. If not, return to step 2.

Results

The search occurred in all non-profit and institutional repositories listed by GETresources [25], a website developed by the Syracuse University with the purpose of sharing and improving OERs. The full list of repositories considered in our work is displayed in the Table 8.

Although we have considered several open repositories, only four of them had in their libraries Software Engineering mate-

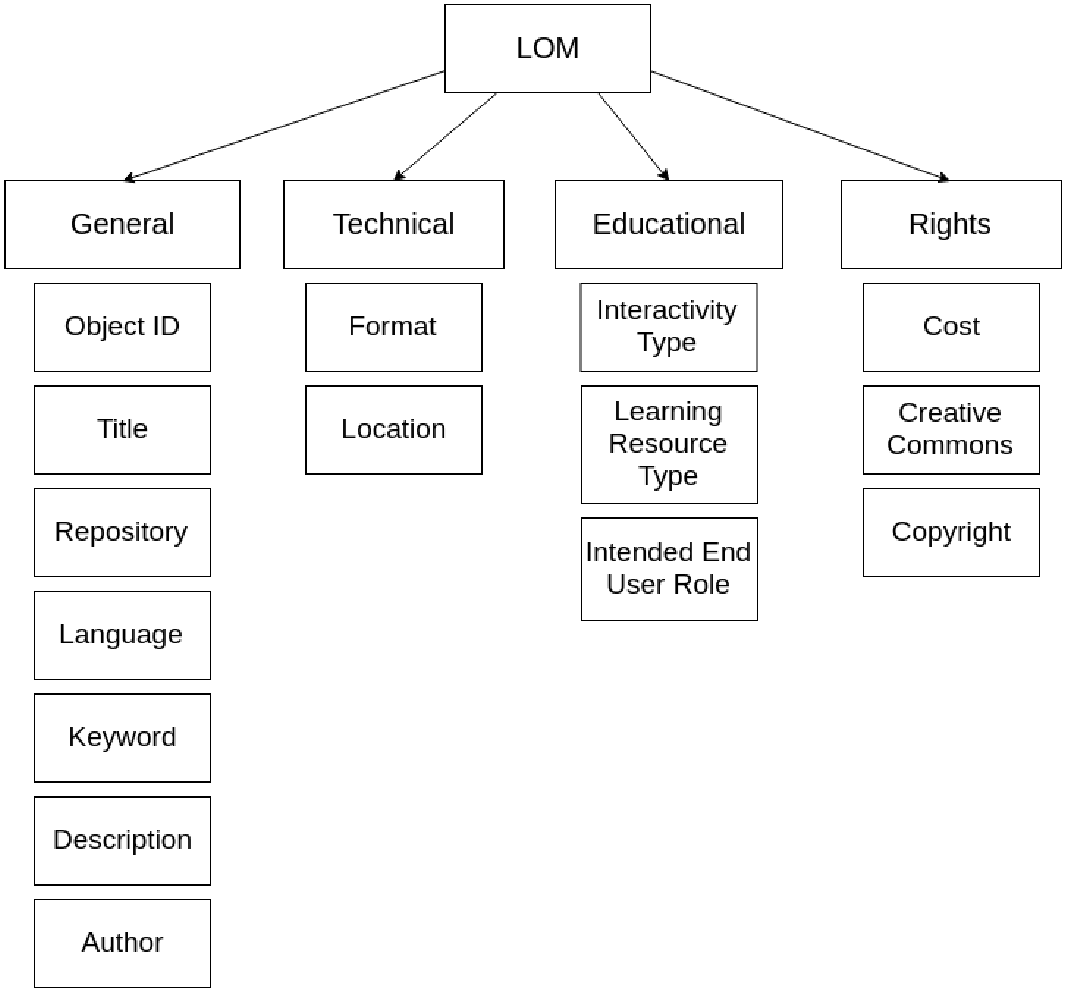

Figure 4. Metadata Structure Adopted

rials. The total amount of returned SE LOs per repository is shown in Figure 5.

The whole searching process returned a total of 112 LOs for Software Engineering from the open access repositories considered in our research.

According to Figure 5, MERLOT presents the highest number of retrieved LOs for Software Engineering, with 66 items. The second one was OpenStax CNX, with 35 items. WISC and UK Open Learning provided 6 and 5 items, respectively.

MERLOT is a repository of the California State University and presented the highest number of returned learning objects. Its stats are high due to the several partners that regularly contribute to its pool of learning objects [17]. Notice that MIT Open Courseware and Saylor.org are some of these partners, reason why they did not appear with results in Figure 5.

OpenStax CNX is a non-profit organization maintained by the University of Rice, whose objective is to improve student access to education [4]. Its results were the most diverse in terms of language (LOs in English, Spanish and Portuguese were retrieved).

WISC corresponds to a collaborative effort of 16 colleges in the Wisconsin Technical College System (WTCS), being designed to use a digital library of learning objects to improve learning for students at WTCS colleges [28]. Although its numbers were relatively low when compared to the other repositories, its contribution is relevant due to the nature of the objects retrieved, being the only repository that came up with educational games.

The complete results are available at https://goo.gl/6uR6u9. Next we summarize the main results in terms of: (i) licenses; (ii) Software Engineering sub-areas occurrence; and (iii) interactivity type among the retrieved LOs.

Licenses

Creative Commons (CC) licenses are public copyright licenses that enables free sharing and distribution of copyrighted work [5]. They were chosen due their main role in open access education, being used in almost every open repository. There are several types of licenses; its occurrences between the objects are displayed in the Figure 6.

BY licenses are the most common, with 42 items. They represent learning resources that can be shared, remixed and

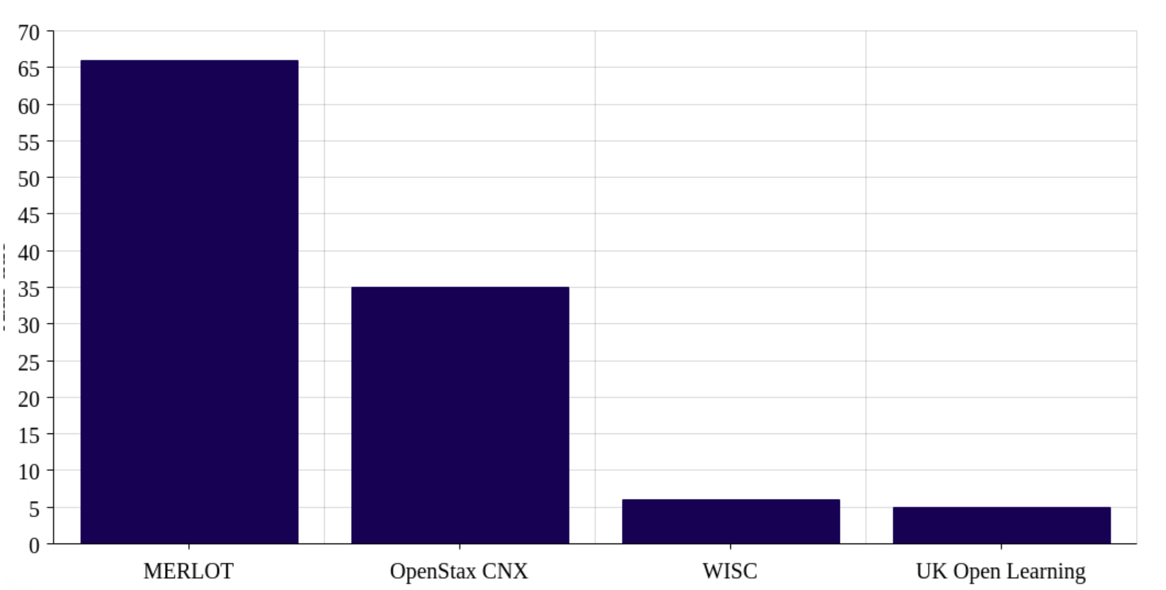

Figure 5. Amount of SE LOs retrieved from each Open Repository

Table 7. Keywords Content

Keyword	Content
Software Requirements	requirements elicitation, requirements validation, process models, process actors, quantifiable requirements, emergent properties, functional and non-functional requirements.
Software Project	design patterns, architectural project, user interface design, dynamic aspect, static aspect.
Software Testing	test techniques, test-related measures, test process, software testing tools.
Software Maintenance	maintenance techniques, reengineering, reverse engineering, migration, retirement, software maintenance tools.
Software Configuration	management of the SCM process, software library, requesting, evaluating and approving software changes, auditing, software configuration management tools.
Project Management	scope, effort, schedule, cost estimation, risk management, closure, resource allocation, deliverables, project management tools.
Process Models	software life cycles, assessment models, assessment methods, improvement models, cascading method.
Software Modeling	UML, information modeling, behavioral modeling, structure modeling, prototyping methods, heuristic methods, formal methods, agile methods.
Software Quality	verification, validation, functionality, reliability, usability, efficiency, maintainability, portability.

adapted by any person, as long they attribute the credit to the origin creator, being the most flexible license.

Table 8. List of Searched Repositories

Repository Name	URL
MIT Open Courseware	ocw.mit.edu
edX	edx.org
Stanford Online	shorturl.at/knoyJ
WISC - Online	wisc-online.com
NCLOR	explorethelor.org
KLD	kylearningdepot.org
OpenStax College	openstax.org
Saylor.org	saylor.org
Open Textbook Library	shorturl.at/kqswW
MERLOT	merlot.org
OER Commons	oercommons.org
ARIADNE	shorturl.at/huOTX
Primo	primodb.org
JORUM	jisc.ac.uk
NSDL	nsdl.org

BY-NC-SA licenses appear in second place, with 18 items. They have the same characteristics of *BY licenses*, but they cannot be used with commercial intent and their derived creations must follow these same legal conditions.

BY-NC-ND licenses are the most restrictive of the licenses, found in seven resources. Such kind of license only allows the users to download and share the content, but it cannot be used with business purposes and cannot be adapted or altered.

Although most of the Software Engineering LOs retrieved were attached to some kind of sharing, there was a significant number of items (40) that did not report whether they have a license or not. This implicates in the open repositories proposal of educational sharing, since it is fundamental for students and educators to know the legal limits bound to the learning materials being used.

Software Engineering Sub-Areas

Figure 7 shows the most prevalent Software Engineering sub-areas found among the retrieved LOs. It also shows, for each

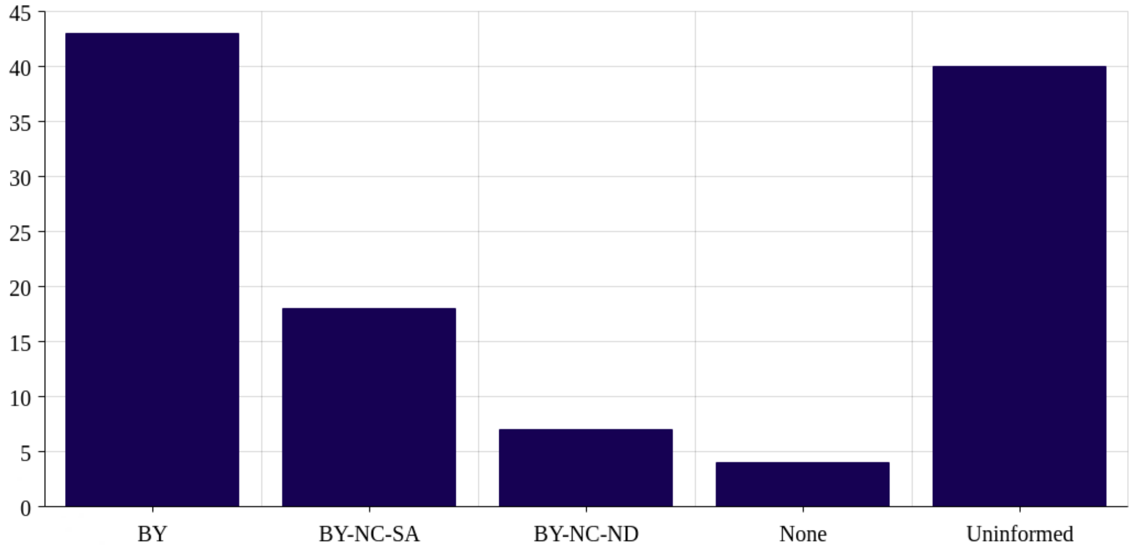

Figure 6. Creative Commons licenses distribution

sub-area, how much of the retrieved items are actually OERs (have a CC license), Non-OERs (explicitly specify that do not possess a CC license) or Uninformed (do not report whether it have a license or not).

Project Management presented the highest number of occurrences, appearing in a total of 34 items, where 14 of them were OERs, 19 were Uninformed and 1 was a Non-OER. *Software Project* also appeared with high numbers, 12 OERs and 11 Uninformed, in a total of 23 items.

Software Testing, *Software Quality*, *Software Configuration*, in turn, were the sub-areas with the lowest results. They had a total of 3, 3 and 2 items retrieved, respectively.

Software Engineering have the highest relative number of Uninformed occurrences, almost 80% of the 14 returned items. Among the sub-areas with more than 10 items, *Software Maintenance*, *Software Engineering*, and *Process Models* presented the highest relative number of OERs, 90%, 77% and 75%, respectively.

Interactivity Type

The LOs retrieved from our search were also analyzed according to three main types of interactivity [11]: active, expositive and mixed learning.

Active learning is supported by content that directly induces productive action by the learner, like questionnaires, exercises. *Expositive learning* occurs when the learner's task mainly consists of absorbing the content exposed to him/her, mainly through graphic materials, hypertext documents or video clips. Finally, When a learning object blends the active and expositive interactivity types, then its interactivity type is considered *Mixed*.

Figure 8 shows the distribution of interactivity type among the LOs. It also displays the distribution of OERs, Non-OERs and Uninformed items (in the same way as in Figure 7). We noticed a high prevalence of expositive documents over the other interactivity types. It was also clear that all the three interactivity types presented closely the same distribution of OERs, Non-OERs and Uninformed results.

CONCLUSIONS

In this paper we have investigated the current state of adoption of OERs in the context of Software Engineering area. Both top universities and open repositories were inspected in this regard.

The main contribution of this study was to provide an overview on how the world top universities and the open access repositories are producing and delivering OERs for Software Engineering. Our goal was to gather the main characteristics of the available Software Engineering OERs in the repositories and to rank the effort of the universities to the open access movement, particularly in the SE courses.

In general, we noticed that most of the SE sub-areas have not been well-covered in terms of open educational resources in the existing repositories. Our research also revealed that expositive is still the most common interactivity type among the learning materials available. Moreover, our findings exposed the lack of copyright licenses information in a significant portion of the retrieved materials. In the academic setting, we found that the majority of the top institutions in Computer Science have still not being able to successfully share the SE knowledge to the public.

As future work, we highlight the need of performing a more detailed analysis of our results in an attempt to investigate the real causes of the problems herein found. We also intend to conduct a systematic mapping of the literature on the development and delivery of Software Engineering OERs. At the very end, we intend to investigate and propose ways to encourage the production and effective adoption of OERs in the Software Engineering area.

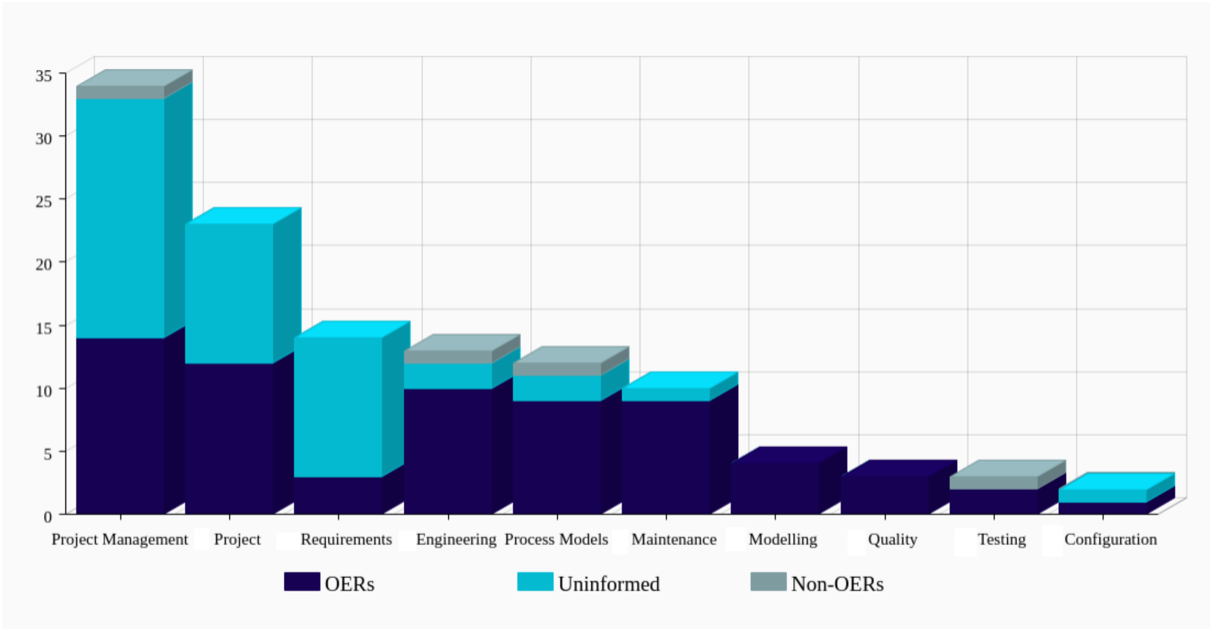

Figure 7. SE Sub-Areas Occurrence

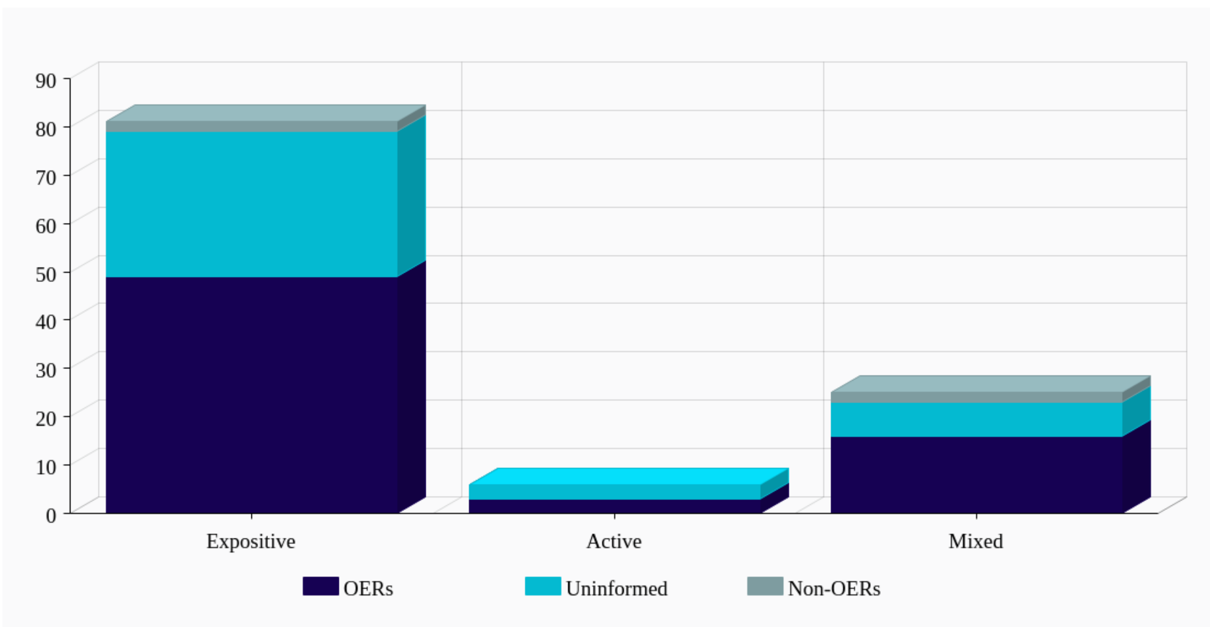

Figure 8. Interactivity Type

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REFERENCES

[1] David A. Wiley. 2007. The Learning Objects Literature. In *Handbook of Research on Educational Communication and Technology*. Springer-Verlag New York.

[2] Maurício Arimoto. 2012. A Systematic Review of Methods for Developing Open Educational Resources. In *Conference: 20th International Conference on Computers in Education (ICCE'2012), At Singapore, Volume: 20*.

[3] Phil Barker. What is IEEE Learning Object Metadata / IMS Learning Resource Metadata? (????). 2005.

[4] OpenStax CNX. 2018. Sharing Knowledge and Building Communities - OpenStax CNX. `https://cnx.org/`. (2018). Acessed: 2018:03:16.

[5] Creative Commons. 2018. Creative Commons Brazil. https://goo.gl/jncmBV. (2018). Acessed: 2018:03:16.

[6] Dublin Core. 2018. DCMI: Home. http://dublincore.org/. (2018). Acessed: 2018:03:16.

[7] Folha de São Paulo. 2018. RUF; Ranking das Universidades do Brasil | Folha. https://goo.gl/bdtPdE. (2018). Acessed: 2018:03:16.

[8] Jhonatan Ferlin, Avanilde Kemczinski, Edson Murakami, Marcelo Da, and Marcelo Hounsell. 2010. Metadados Essenciais: Uma Metodologia para Catalogação de Objetos de Aprendizagem no Repositório Digital ROAI. In *In Conference: Workshop Informática na Escola (WIE 2010)*.

[9] Brenda Gourley and Andy Lane. 2009. Re-invigorating openness at The Open University: the role of Open Educational Resources. *Open Learning: The Journal of Open, Distance and e-Learning* 24, 1 (2009), 57–65. DOI:http://dx.doi.org/10.1080/02680510802627845

[10] Willian Hewlett and Flora Hewlett. 2018. Open Educational Resources. https://goo.gl/KZTQQ1. (2018). Acessed: 2018:03:16.

[11] IEEE. 2002. IEEE Standard for Learning Object Metadata. (2002).

[12] IEEE. 2018. SWEBOK Guide to the Software Engineering Body of Knowledge. (2018). Version 3.0.

[13] Neil Jacobs. 2006. *Open Access: Key Strategic, Technical and Economic Aspects* (1 ed.). Chandos Publishing.

[14] Ambikesh Jayal and Martin Shepperd. 2007. An evaluation of e-learning standards. In *5th International Conference on E-Governance, Hyderabad, India, Dec 28-30, 2007*.

[15] Eugenijus Kurilovas and Valentina Dagiene. 2009. Learning Objects and Virtual Learning Environments Technical Evaluation Criteria. *Electronic Journal of e-Learning* (2009), 127–136.

[16] LABES. 2018. Material Didático | LabES. https://goo.gl/fsKkj8. (2018). Acessed: 2018:03:17.

[17] MERLOT. 2018. MERLOT Partners. https://goo.gl/UByVn9. (2018). Acessed: 2018:03:16.

[18] Moodle. 2018. IMS content package - Moodle Docs. https://goo.gl/aidpMX. (2018). Acessed: 2018:03:16.

[19] Massachusetts Institute of Technology. 2018. MIT OpenCourseWare | Free Online Course Materials. https://goo.gl/h5vWAu. (2018). Acessed: 2018:03:16.

[20] Ana M.B. Pavani. 2016. An Overview of Repositories of Learning Objects. *IFAC-PapersOnLine* 49, 6 (2016), 174 – 179. DOI:http://dx.doi.org/https://doi.org/10.1016/j.ifacol.2016.07.173 11th IFAC Symposium on Advances in Control Education ACE 2016.

[21] Rustici Software. 2018. SCORM Explained. https://goo.gl/PzQai9. (2018). Acessed: 2018:03:16.

[22] UKOLN. 2018. UK LOM Core - Education - Metadata - UKOLN. https://goo.gl/agxfTB. (2018). Acessed: 2018:03:16.

[23] UNAM. 2018. Buscar | Media Campus. https://goo.gl/JYPnfX. (2018). Acessed: 2018:03:17.

[24] Top Universities. 2018. Top Universities | Worldwide University rankings, guides and events. https://www.topuniversities.com/. (2018). Acessed: 2018:02:27.

[25] Syracuse University. 2018. Repositories | Open Educational Resources. https://goo.gl/9dKgYY. (2018). Acessed: 2018:03:16.

[26] M. Villavicencio, H. V. Revelo, and J. Pincay. 2016. Towards the evaluation of open educational resources for learning software engineering. In *2016 XLII Latin American Computing Conference (CLEI)*. 1–9. DOI:http://dx.doi.org/10.1109/CLEI.2016.7833338

[27] Zahid Ashraf Wani, Sumeer Gul, and Javeed Ahmed Rah. 2014. Open Access Repositories: A Global Perspective with an Emphasis on Asia. *Cybrarians Journal* (12 2014).

[28] WISC. 2018. Wisc-Online OER. https://www.wisc-online.com/. (2018). Acessed: 2018:03:16.

[29] Li Yuan, Sheila MacNeill, and Wilbert Kraan. 2008. *Open Educational Resources – Opportunities and challenges for higher education*. Technical Report. Joint Information Systems Committee (JISC) CETIS. 1–34 pages.