Measuring Quality, Popularity, Demand and Usage of Repositories of Open Educational Resources (ROER): A Study on Thirteen Popular ROER

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Abstract. Open Educational Resources (OER) could be used by educators and learners for online teaching and learning. All over the world, various OER repositories and directories curate OER in various subjects. However, little is known about their quality, popularity and usage. This paper investigates and analyses qualitatively and quantitatively thirteen well known Repositories of OER (ROER) from the users' point of view. The following web traffic analytics tools were used: Google MobileFriendly, Google PageSpeed Insights, OpenLink Profiler, SimilarWeb, and WAVE. Most of these ROER curate OER and links pointing to OER of multiple types, multiple languages, multiple disciplines (subjects), and multiple educational levels. Also, almost all of them provide mobile friendly design, some form of OER quality evaluation, and facilities so that anyone can search them for OER and their members can interact, communicate, and collaborate among themselves. However, most of them provide poor speed and their information about their OER does not always correspond to the reality. Most of these ROER have registered members and social media followers, and are well recognised by thousands of websites that point to them. Thousands of users visit these ROER. On average, visitors visit 3.6 pages and spend 2.6 minutes per visit in a ROER. Finally, the paper makes suggestions for the improvement of teaching and learning ROER.

Keywords: OER; OER Repositories; Open Educational Resources; OpenLink Profiler; SimilarWeb; Web Analytics.

Introduction

The outbreak of COVID-19 in 2020 forced almost all governments in the world to impose social distancing and lockdown measures to restrict the pandemic spread. As a result, educational institutions complying with the lockdown decisions had to shift their educational activities to online teaching and learning. However, educational institutions, educators and learners were not prepared for such a massive educational disruption. They were lacking not only digital infrastructure and digital skills but also appropriate digital educational material. Open Educational Resources (OER) could help in filling the gap of digital educational resources' availability. According to UNESCO (2021), OER are learning, teaching, and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license that permits no-cost access, use, adaptation, and redistribution by others. Another popular definition of OER include the 5R's, i.e., the rights to retain (make, create, own, and control copies of), reuse, revise (adapt and modify), remix (combine), and redistribute (share all forms of) the content (Wiley, 2014).

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In an effort to support educational institutions all over the world in their transition to OER-based education, the Commonwealth of Learning (COL) and the network of Open Education Resource universitas (OERu) cooperated with the UNESCO Institution for Information Technologies in Education (IITE) and the International Council for Open and Distance Education (ICDE) to implement the OER4Covid initiative (OER4Covid, 2021). Similarly, the Driving OER Sustainability for Student Success (DOERS3, 2021) urges higher education institutions to accelerate the adoption of high-quality OER. DOERS3 is a collective of 23 higher education systems and state/province-wide OER initiatives representing approximately 6 million students across 650 colleges and universities in the U.S. and Canada. According to DOERS3 (2021), OER has four advantages over traditional textbooks in the COVID-19 learning environment: i) Remote-instruction friendly; ii) Adaptable; iii) Accessible for ever; iv) A good investment.

OER not only enable cost savings (Hilton III et al., 2014; Hilton, 2016; Hilton et al., 2019; Weller et al., 2015) but they can also increase students' autonomy, experimentation with new ways of learning, satisfaction, interest in the subjects taught, and enthusiasm for future studies as well as collaboration amongst learners and among teachers (Authors, 2020; Blyth, 2012; de los Arcos et al., 2016; Sabadie et al., 2014; Weller et al., 2015). Furthermore, open textbooks can be of higher quality than copyright-restricted textbooks (Kimmons, 2015).

However, there is a variety of obstacles that prevent the worldwide adoption of OER (Abeywardena et al., 2012; Authors, 2020, 2021; Belikov & Bodily, 2016; Hu et al., 2015; Luo et al., 2020; McGowan, 2020). Some of these obstacles are related to the Repositories of OER (ROER). According to UNESCO (Huang et al., 2020), a ROER curates OER for later search, retrieval, and use while an OER Directory lists digital links pointing to OER stored elsewhere. This paper uses the term ROER to include both types. Previous studies found that it is difficult to find effective ROER and appropriate OER (Abeywardena et al., 2012; Allen & Seaman, 2016; Atenas et al., 2014; Atkins et al., 2007; Belikov & Bodily, 2016; de los Arcos et al., 2015; de los Arcos et al., 2016; Hodgkinson-Williams & Arinto, 2017; Hu et al., 2015; Luo et al., 2020; Mishra & Singh, 2017; Muthu & Cheng, 2019; Seaman & Seaman, 2017). For example, during the OER Research Hub project funded by the Hewlett Foundation, data collected from approximately 7,500 users of OER around the globe revealed that 53.3% of educators faced challenges in "Knowing where to find resources" and 58.2% of them in "Finding suitable resources in my subject area" (de los Arcos et al., 2015). Also, a review on 51 OER studies conducted in countries across the five continents found that OER discoverability is a significant barrier preventing OER adoption at HE institutions (Luo et al., 2020).

Development of effective and ease-to-use ROER could facilitate OER adoption in order to achieve UNESCO objectives for "effective, inclusive and equitable access to quality OER" and "sustainability models for OER" (UNESCO, 2019). Previous studies on ROER sustainability (Annand, 2015; Kanwar et al., 2010; McGreal, 2017) suggested the ROER to be hosted or managed by an established organization. Furthermore, effective ROER should provide the following facilities:

- OER searchability (e.g., Authors, 2021, 2021; Atenas et al., 2014);
- OER quality evaluation tools (e.g., Atenas et al., 2014; Atenas & Havemann, 2013; Clements et al., 2015; Connell & Connell, 2020; Huang et al., 2020);
- Multilingual interface and support (e.g., Atenas & Havemann, 2013; Atenas et al., 2014; Huang et al., 2020);

- Standardized metadata and comprehensive description of OER (e.g., Atenas & Havemann, 2013; Atenas et al., 2014; Connell & Connell, 2020; Huang et al., 2020; Kawachi, 2015);
- Collaboration and sharing tools such as social media and communities (e.g., Atenas & Havemann, 2013; Atenas et al., 2014; Clements et al., 2015; Kawachi, 2015);
- Creative Commons (CC) Licenses for OER (e.g., Atenas & Havemann, 2013; Atenas et al., 2014);
- Comprehensive content (e.g., Authors, 2021, 2021; Hu et al., 2015).

Regarding taxonomies of ROER, McGreal (2017) proposed three types of ROER: i) local hosting of content, ii) local hosting of metadata with links to OER stored at other sites, iii) hybrid sites that host both content and links. ROER can also be classified with respect to the content subject areas: i) general repositories that host content from various subjects and ii) specific repositories that host content in specific subject area. Atenas and Havemann (2013) proposed the following ROER types: regional, National, International, Institutional, Consortium.

Another taxonomy (Santos-Hermosa et al., 2017) categorized ROER with respect to the following criteria: i) OER stored wholly or partially, ii) Discipline, iii) Person responsible or creator, iv) Geographical origin, v) Software/Platform, and vii) Metadata standard. However, for someone looking to find appropriate OER for a specific educational purpose, the Per-son responsible or creator, the Geographical origin, the Software/ Platform, and the Metadata standard do not really matter. Actually, very few ROER provide OER that adhere to educational standards (Santos-Hermosa et al., 2017). Also, in our interconnected world, there are not any more geographic boundaries but there are still language barriers.

This paper investigates ROER with respect to their type, the provided facilities (e.g., search engine, open licensing, OER evaluation, members' community), their popularity, and usage. More specifically, this paper tries to answer the following research questions:

- What are the ROER types?
- What is the quality of 13 well-known ROER for teaching and learning?
- What is the popularity of 13 well-known ROER for teaching and learning?
- What is the demand and usage of 13 well-known ROER for teaching and learning?

The next section describes the six-stages methodology that was followed to define to select the ROER, the web analytics tools to be used and the metrics for measuring the ROER. The analysis of the ROER follows as well as the presentation and discussion of the results. Finally, the paper presents the conclusions and makes recommendations.

Methodology

This study took place during January to April 2021. A six-stages methodology was followed: 1) Definition of the measures to determine the ROER types, quality, popularity, and usage; 2) Discovery and identification of well-known ROER for teaching and learning; 3) Exploration of the identified ROER; 4) Selection of ROER to be analysed; 5) Analysis of the selected ROER; 6) Reporting the results.

Based on previous studies analysed in the Introduction, this paper suggests the following categories of OER Repositories from the users' point of view (Table 1) with

respect to: the OER type that they contain (e.g., course, textbook, lesson plan, video lecture, case study, assessment), the OER language (e.g., only in English, in multiple languages), the OER discipline (subject) (e.g., only in science learning, in multiple disciplines), the OER educational level (e.g., appropriate for pupils, for adults), the OER content (e.g., appropriate for teaching and learning, for research, software), the OER details (e.g., ROER contains the whole OER, link to the OER), as well as the ROER host and nationality.

[Insert Table 1]

As it was described in the Introduction, an effective ROER should provide facilities such as easy searchability of OER, multilingual interface, rich content, users' community, as well as OER that have open licenses and have been evaluated for quality. This paper will investigate well-known ROER for teaching and learning using in-site extensive exploration of their websites as well as automatic traffic analysis using web analytics tools such as Google Mobile-Friendly (2021), Google PageSpeedInsights (2021), OpenLink Profiler (2021), SimilarWeb (2021), and WAVE (2021).

So, regarding the ROER quality this paper will evaluate the existence of the following parameters: 1) multilingual interface, 2) searchability, 3) members' community, 4) size (number of materials, textbooks, courses), 5) resources with an open license, 6) OER being evaluated, 7) website speed, 8) mobile friendly, and 9) accessibility.

Regarding the ROER popularity this paper will evaluate the following parameters: 1) number of members, 2) number of followers in social media (Facebook followers, LinkedIn followers, registered users in YouTube channel) 3) number of websites pointing to it, and 4) number of links (more than one link can come from the same website) pointing to it.

Regarding the ROER demand and usage this paper will evaluate the following parameters: 1) number of visits in the last six months, 2) visits by top three countries, 3) visits by originating source, 4) average number of pages per visit, 5) average visit duration, and 6) bounce rate (percentage of visitors that leave the website after viewing just one page).

In order to identify popular ROER, multiple sources were investigated. Santos-Hermosa et al. (2017) identified 110 repositories using as sources ROAR, Open DOAR, Open Education Europe and EdReNe. The current study investigated information and tutorials about ROER in over fifty websites of Universities' Libraries (e.g., https://guides.library.ubc.ca/open-education/finding), over twenty e-toolkits for OER teaching and learning (e.g., https://www.k-state.edu/keepteaching/docs/oer-toolkit.pdf), the Registry of Open Access Repository (ROAR, http://roar.eprints.org/) which monitors 4537 repositories throughout the world, and the Directory of Open Access Repositories (Open DOAR, http://v2.sherpa.ac.uk/opendoar/) which registers 5220 repositories.

However, it was not an easy task to explore the identified ROER. Even well-known ROER paused their operation and do not exist anymore (e.g., Orange Gove, https://www.floridashines.org/orange-grove, TEMOA, http://www.temoa.info/, CNX is retiring: https://cnx.org/). Since, we speak the English language and do not speak other popular languages (such as Chinese, Arabic, or Spanish), we restricted the exploration of ROER to those that either provide English menus or the web browser's Google translator provides an English translation. Some other encountered obstacles were that many search engines did not provide accurate results, many ROER curated very few OER, many ROER did not curate really open OER (e.g., only provide a limited time free trial or a

free sample of the material), and many Institutional ROER contained a mixture of OER for research (e.g., research articles, dissertations) together with few OER for teaching and learning produced by the local faculty.

Eventually, the following (alphabetically) thirteen ROER for teaching and learning were selected based on their popularity, English language, size, comprehensiveness, and freshness:

- **Commons (by Canvas)**: https://lor.instructure.com/
- **Curriki**: https://library.curriki.org/
- **DOER (Directory of Open Educational Resources)**: http://doer.col.org/
- **KlasCement**: https://www.klascement.net/?hl=en
- **Mason OER Metafinder (MOM)**: https://oer.deepwebaccess.com/oer/desktop/en/search.html
- **MERLOT (Multimedia Education Resource for Learning and Online Teaching)**: https://www.merlot.org/merlot/
- **MIT OpenCourseWare (OCW):** https://ocw.mit.edu/index.htm
- **OASIS (Openly Available Sources Integrated Search)**: https://oasis.geneseo.edu/
- **OER Commons**: https://www.oercommons.org
- **OER World Map**: https://oerworldmap.org/
- **OpenLearn**: https://www.open.edu/openlearn/
- **OpenStax:** https://openstax.org/
- **Open Textbook Library:** https://open.umn.edu/opentextbooks/

These thirteen ROER for teaching and learning will be further analysed in the next section.

ROER Analysis

After extensively exploring each ROER, based on the taxonomy of Table 1, the basic characteristics of all thirteen ROER are presented in the following Table 2.

[Insert Table 2]

Most of these ROER are hosted by an Institution and curate OER and links to OER of mixed types, multiple languages, multiple disciplines (subjects), and multiple educational levels. For example, OER Commons is an Institutional ROER with an English language interface curating mixed-type, multilanguage, multidisciplinary, multi-educational level educational resources and links to educational resources.

Next, by investigating and searching extensively inside each ROER using various search methods, filters, and keywords this paper recorded the following data: 1) interface language, 2) searchability, 3) members' community, 4) total number of all materials, 5) number of textbooks, 6) number of courses, 7) number of OER with open licenses, and 8) number of educational resources that have been evaluated by peers or editors (Table 3a,b). Then the ROER speed was measured using Google PageSpeedInsights (2021) which reports on the performance of a page on both mobile and desktop devices. A score of 90 or above is considered good. A score between 50 to 90 means that the website needs improvement, and a score below 50 is considered poor. The ROER mobile friendliness was measured by Google Mobile-Friendly (2021). Finally, the number of accessibility errors in the first page of each ROER was measured by WAVE Web Accessibility

Evaluation Tool (2021). When the relevant information in a ROER is not clear, a question mark "?" is shown. When an affordance is not provided, a dash "---" is shown.

[Insert Table 3a]

[Insert Table 3b]

Table 3a shows that almost all ROER provide an interface in English, a search engine and a community. The number of educational materials and links in each ROER varies from few thousands to few hundreds of thousands while the number of textbooks and full courses in each ROER varies form few hundreds to few thousands. The number of OER with open licenses varies from few hundreds to several thousands and the number of reviewed materials varies from few hundreds to few thousands among different ROER (Table 3b). Furthermore, textbooks, full courses, OER with open licenses and reviewed material constitute only a small fraction among all educational materials in each ROER. Further discussion of the results is given in the next section.

Regarding the ROER popularity, this paper measured the number of ROER's members as it was reported by each ROER on its website and the number of its followers in social media by visiting the ROER presence in Facebook, LinkedIn, and YouTube. Table 4 shows a "---" in cases that this ROER does not have a presence in that social media. Finally, the numbers of websites and links pointing to the ROER were given by the OpenLinkProfiler (2021) on March 2021 (Table 4).

[Insert Table 4]

Table 4 illustrates that most of these ROER have registered members and social media followers. However, these numbers highly vary among different ROER. The number of websites pointing to a ROER varies from few hundreds to few thousands while the number of links pointing to it varies from few thousands to few hundreds of thousands. MIT OCW shines as a best-case exception. Further discussion of the results is given in the next section.

Finally, this paper evaluated the demand and usage of each ROER using the web traffic analytics tool SimilarWeb (2021) and measuring the following parameters: 1) total number of visits in the last six months, 2) percentage of visits by top three countries, 3) percentage of visits coming from search engines, directly to the ROER, and from referring websites to the ROER (the rest visits come from social media, emails, and advertising), 4) average visit duration (min:sec), 5) average number of pages per visit, and 6) bounce rate (percentage of visitors that leave the website after viewing just one page) during February and March 2021. SimilarWeb did not give any results for Curriki, DOER, MOM, OASIS, and OER World Map.

[Insert Table 5]

Table 5 illustrates that the number of visits to a ROER during the last six months varies from few hundreds of thousands to few millions among different ROER. Also, the average visit duration varies from less than 1 minute to over 5 minutes while the number of pages per visit varies from about 2 to over 8 pages per visit among different ROER. Further discussion of the results is given in the next section.

Results and Discussion

Most ROER provide a mix of various educational resources types in multiple disciplines (subjects), educational levels, and languages as well as links to resources. However, a user looking for OER in a specific subject may be lost among all these different ROER. It would be useful to also exist specialized ROER for specific discipline (subject). Although there are some specialized ROER for languages (e.g., COERLL: https://www.coerll.utexas.edu/coerll/) and mathematics (e.g., GeoGebra: https://www.geogebra.org/materials) it would be interesting to also develop specialized ROER for all disciplines (subjects) at various educational levels. So, a teacher or learner interested in a specific subject and educational level would visit directly this ROER to find any appropriate OER for his/her specific educational objective.

Some Institutional ROER provide specific OER corresponding to courses taught at that University (Table 2). For example, MIT OCW provides open full courses in English taught at MIT on many disciplines at undergraduate and graduate levels. Similarly, OpenLearn provides open full courses and other OER in English taught at The Open University (UK) in English on many disciplines at undergraduate and graduate levels. Also, Open Textbook Library and OpenStax specialize to provide open textbooks.

Almost all ROER provide facilities so that anyone can search them for OER and their members can interact, communicate, and collaborate among themselves. Although the numbers show (Table 3a) that some of these ROER provide access to many resources, the reality is different. The data given by each ROER do not always correspond to the reality and many of these results are not useful. For example, a meta-search engine gave a much larger number of courses at a ROER than the number of courses stored at that ROER. In another example, a ROER reported a number of "courses" but not all of these "courses" were full courses; a lecture, a chapter, or a presentation may have been counted as a full course. Most of these educational resources are bits and pieces of educational material and not autonomous and complete educational resources. OASIS and Commons seem to provide access to most educational resources (including links) (Table 3a). Among all resources in each ROER, the percentages of courses range from 1.3% in Curriki to 39% in DOER (1.66% in OASIS, 8.6% in Merlot, 12% in OER World Map, 13.3% in Commons). Similarly, the percentages of textbooks range from 0.2% in Curriki to 8.4% in Merlot (0.6% in KlasCement, 0.6% in OASIS, 1.1% in OER World Map, 1.4% in Commons). In addition, not all of these courses are full courses. Many ROER have catalogued a lecture or a presentation as a course. Similarly, they have catalogued a book chapter as a textbook. All these problems originate from the lack of universally accepted standards to describe the educational resources metadata as well as the curators and authors arbitrariness when filling in these metadata.

Furthermore, it is not clear how many of all these resources are really open. Only MIT OCW, OpenLearn, OpenStax, and Open Textbook Library state clearly that all of their OER have open licenses (Table 3b). Regarding the rest ROER, the results show that 64% of the resources have open licenses in KlasCement, 41% in Merlot, 60% in OASIS and 7% in OER World Map. However, according to many (e.g., Open Textbook Library, 2021; Wiley, 2014), licenses with remixing (derivatives) restrictions are not considered OER. Therefore, many of these resources are not really OER. Regarding the OER quality assurance, MIT OCW, OpenLearn, OpenStax, and Open Textbook Library state that almost all of their resources have been reviewed to ensure their quality standards (Table 3b). In the rest ROER, the percentages of resources reviewed by peers and editors and 2% and 12% in Curriki, 5.9% and 4.7% in MERLOT, as well as 0.2% in OASIS. Therefore, it is clear that most resources in ROER have not been evaluated by anyone.

The speed of a platform is extremely important in order to best serve its users. Users are not satisfied when wait for a page for long time. However, none of these ROER provides a good speed (score above 90); most ROER provide poor speed (score below 50) (Table 3b). The meta-search engines MOM and DOER have the best speeds, while Commons the lowest speed. Most ROER support mobile friendly design. However, Commons and MIT OCW have some issues. Recognizing the importance of supporting the users' mobility, MIT OCW plans to launch NextGen which will be a mobile-friendly platform (NextGen, 2021). Regarding the ROER mobile friendly design, the usual problems are that the text is too small to read in a mobile device and clickable items are very close to each other. Finally, an indication of the ROER accessibility is the number of accessibility errors in the first page. Commons, MOM, Merlot, and OASIS show no errors, while Curriki and MIT OCW show many errors.

One way to promote the OER spreading for educational purposes is to develop users' communities. OER curators, authors, teachers and learners would participate in such communities communicating, collaborating and exchanging ideas, challenges, recommendations, solutions and OER. Indeed, most ROER support members' communities on their platforms as well as on social media (Table 4). A ROER could attract and keep on users in its social media groups informing them on new developments of its platform and open education in general. Also, its social media groups would promote its platform and its innovations attracting more users.

Curriki, KlasCement, and MERLOT have hundreds of thousands registered members. However, they only have few hundreds to few thousands of social media followers. MIT OCW seems to be the most successful with its social media. It presents its open lectures to almost 3M registered users in its YouTube channel. It also has almost half a million followers to its Facebook presence. Similarly, OpenLearn has more than a quarter of a million registered users in YouTube and over thirty thousands of Facebook followers.

Thousands of websites recognize the importance and point to most of these ROER (Table 4). MIT is clearly considered the most reputable ROER and over thirty thousands of websites point to it with almost 1M links. Around 5K to 7K websites and 85K to 220K links point to each of the OpenLearn, OER Commons, MERLOT, and Curriki. Fewer website and links point to the rest ROER. Actually, very few websites point to DOER and MOM.

During the last six months, millions of visitors visited OpenStax (4.39M), MIT OCW (4.23M) and OpenLearn (2.56M) (Table 5). Also, several hundreds of visitors visited Open Textbook Library (545.1K), KlasCement (354.64K), OER Commons (173.63K), MERLOT (131.74K). It is remarkable that although MERLOT has many registered users and many websites point to it, not too many visitors visit it. Overall, ROER do not achieve any extraordinary success even during this OER-needed period of schools' lockdown. For example, although MIT OCW stands for its reputation, the number of its visits during the last six months is not remarkable (comparing, for example, to the 54.44M visits to mit.edu and 55.21M visits to harvard.edu).

Most visitors to a ROER come from the country where it is located (Table 5). So, the percentage of U.S. visitors are 80% in Commons, 82% in OpenStax, 71% in OER Commons, 57% in Open Textbook Library, 39% in MIT OCW, and 31% in MERLOT. The 39% of visitors to OpenLearn come from U.K. while the 65% of visitors to KlasCement come from Belgium. It seems that visitors to MERLOT, MIT OCW, and OpenLearn come from all over the world. Visitors come to most OER (KlasCement, MERLOT, MIT OCW, OpenLearn, Open Textbook Library) after visiting a search engine while visitors come directly to fewer ROER (Commons, OER Commons, OpenStax).

On average, visitors visit 3.6 pages and spend 2.6 minutes per visit in a ROER. Clearly, users spend most time per visit in OpenStax and KlasCement (around 5 minutes). They spend around 3 minutes per visit in OpenLearn, MIT OCW, and OERCommons. The longer time that a visitor spends in a ROER may mean that he/she finds useful resources to investigate. If he/she does not find anything useful then he/she will depart from the ROER. The bounce rate measures exactly this behaviour. The bounce rate is the percentage of visitors that leave the website after viewing just one page. Indeed, the bounce rate is low for OpenStax (49%) and KlasCement (40%). On the other side, Common and MERLOT have the highest bounce rates (65% and 68%, respectively) and low average visit duration (53 sec and less than 2 minutes, respectively).

When a visitor stays long time in a ROER, he/she may visit many pages. Visitors visit more than 8 pages per visit in ClasCement, and around 3 pages per visit in OpenLearn, MIT OCW, OpenStax, and OER Commons. They visit around 2 pages per visit in Commons and Open Textbook Library.

Conclusions, Recommendations, Limitations, and Future Research

OER are stored in ROER. Although there are thousands of ROER all over the world, little is known about their status and usage. This paper categorizes various ROER types and investigates the quality, popularity, and usage of well-known ROER for teaching and learning. It explores these ROER using in-site extensive examination as well as web analytics tools such as Google MobileFriendly (2021), Google PageSpeed Insights (2021), OpenLink Profiler (2021), SimilarWeb (2021), and WAVE (2021).

Most of these ROER curate OER and links to OER of mixed types, multiple languages, multiple disciplines (subjects), and multiple educational levels. Also, almost all of them provide mobile friendly design, some form of OER quality evaluation, as well as facilities so that anyone can search them for OER and their members can interact, communicate, and collaborate among themselves. However, most of them provide poor speed and their information about their OER does not always correspond to the reality. Actually, many of their educational resources are not really OER. Most of these ROER have registered members and social media followers, and are well recognized by thousands of websites that point to them. Although thousands of visitors visit these ROER, the numbers of visitors are not impressive considering the worldwide population of educators and learners. On average, visitors visit 3.6 pages and spend 2.6 minutes per visit in a ROER.

However, the reported numbers in this study should be taken as indicators and trends rather than absolute numbers since they change day-by-day. Furthermore, the numbers given from the website analysis tools should not be considered as 100% accurate. These numbers should be considered as estimates of where a ROER stands in comparison to other ROER.

Administrators and managers of ROER should try to provide accurate search engine, mobile-friendly and accessible design, high speed servers, educational resources that have clear open licenses, and OER that have been evaluated by experts. They should clean the information about their curated OER or links pointing to OER since their ROER may contain inaccurate description of their OER, duplicate OER, obsolete OER, broken and inaccurate links and many more problems. It is important to follow quality assurance procedures in all curation activities. Training the librarians, curators and authors would enable them to correctly fill in metadata information. Following universally accepted standards regarding ROER design and OER metadata would enable the ROER interconnection and collaborative recommendations of OER to users.

Future research may evaluate ROER using other quality parameters such as usability, interoperability, security, personalization, etc. For example, the usability of ROER could be evaluated using appropriate methods and frameworks (e.g., System Usability Scale, Eye Tracking). Also, future research may investigate ROER in other languages (e.g., Chinese, Arabic, Spanish) although it would be useful that the whole ROER to be automatically translated in any language. Also, future research may further investigate specialized ROER that contain teaching and learning OER in specific discipline (subject) and educational level as well as ROER that contain open data, open research (e.g., articles, dissertations) or open software.

Acknowledgments

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Table 1. Taxonomy of ROER from the users' point of view.

OER characteristics	*Repositories of OER (ROER)*
OER type	• Mixed OER-types Repository that contains a mix of OER types such as open textbooks, courses, videos, assessments; • Single OER-type Repository that contains only one OER type, for example, Textbook ROER, Video Lectures ROER, Presentations ROER, Assessments ROER, Courses ROER.
OER language	• Multilanguage ROER that contains a mixture of OER in various languages; • Single language ROER that contains OER only in a specific language, e.g., Arabic ROER, Chinese ROER, French ROER.
OER discipline	• Multidisciplinary ROER that contains OER in multiple educational disciplines (subjects); • Single discipline ROER that contains OER only in a specific educational discipline/subject, e.g., Biology ROER, Geography ROER, History ROER, Language ROER, Mathematics ROER.
OER edu level	• Multiple educational levels ROER; • Primary education ROER; • Secondary education ROER; • Tertiary and higher education ROER; • Continuing and adult education ROER.
OER content	• Various content ROER that contains OER having any kind of content (not necessarily educational) such as movies, TV serials, music, fantasy or mystery books; • Teaching & Learning ROER that contains useful OER for teaching and learning; • Research ROER that contains useful OER for research such as research papers, dissertations/theses, data; • Software ROER that contain apps and other software (e.g., GitHub).
OER residence	• Local ROER contains the whole OER; • Linked ROER contains OER metadata with link to the OER which is stored elsewhere; • Mixed ROER contains both the whole OER and links to the OER.
ROER host	• Institution, University, School, Company, Association, Ministry, Library, Museum, NGO, Project (e.g., Erasmus+ Project).
ROER nationality	• International ROER that is managed by an International agency and contains OER that interest people all over the world; • Multinational ROER that is managed by a Multinational consortium or contains OER that interest people in specific Nations; • National ROER that is managed by a specific Nation or contains OER that interest people in this Nation.

Table 2. Characteristics of well-known ROER for teaching and learning (where Multi= Multiple).

ROER	OER type	OER language	OER discipline	OER Edu level	OER Residence	Hosting agency
Commons	Mixed	Multi	Multi	Multi	Mixed	Institutional (Canvas, US)
Curriki	Mixed	English	Multi	Multi	Mixed	Institutional (US)
DOER	Mixed	English	Multi	Multi	Mixed	Multinational (COL)
KlasCement	Mixed	Multi	Multi	Multi	Mixed	National (Ministry of Education & Training, Belgium)
MOM	Mixed	Multi	Multi	Multi	Linked Federated Search	Institutional (George Mason Univ., US)
MERLOT	Mixed	Multi	Multi	Multi	Linked Metadata	Institutional (US)
MIT OCW	Courses	Multi	Multi	Higher	Local	Institutional (MIT, US)
OASIS	Mixed	Multi	Multi	Multi	Linked	Multinational (COL)
OER Commons	Mixed	Multi	Multi	Multi	Mixed	Institutional (ISKME, US)
OER World Map	Mixed	Multi	Multi	Multi	Linked	Institutional (hbz, graphthinking GmbH & The Open University of UK, Germany)
OpenLearn	Mixed	English	Multi	Higher	Local	Institutional (The Open University, UK)
OpenStax	Textbooks+	English	Multi	Multi	Local	Institutional (Rice University, US)
Open Textbook Library	Textbooks	English	Multi	Higher	Linked	Institutional (Univ. Minnesota, US)

Table 3a. Quality of well-known ROER for teaching and learning.

ROER	*Interface language*	*Searchability*	*Community*	*Materials*	*Textbooks*	*Courses*
Commons	English	Yes	Yes	188,192	2,618	25,231
Curriki	English	Yes	Yes?	51,757	83 (7,361?)	660
DOER	English	Yes	Yes	7,207	622?	2,805
KlasCement	Dutch & English	Yes	Yes	67,682	407	?
MOM	English	Yes	No	?	?	?
MERLOT	English	Yes	Yes	93,681	7,840	8,099
MIT OCW	English	Yes	No	?	111	2,500
OASIS	English	Yes	No	388,707	2,494	6,448
OER Commons	English	Yes	Yes	? 44,430	2,154	1,966
OER World Map	English	Yes	Yes	6,268	68	761
OpenLearn	English	Yes	Yes	?	?	1,000
OpenStax	English	No	No	?	60	?
Open Textbook Library	English	Yes	Yes	?	857	---

Table 3b. Quality of well-known ROER for teaching and learning.

ROER	Open Licensing	Reviewed by peers; editors	Speed	Mobile friendly	Accessibility Errors
Commons	?	---	7	No	0
Curriki	Yes	1,032 6,652	14	Yes	24
DOER	?	?	70	Yes	4
KlasCement	43,170	Yes	46	Yes	6
MOM	?	---	74	?	0
MERLOT	38,541	5,497 4,381	51	Yes	0
MIT OCW	All	All?	35	No	21
OASIS	232,456	626	35	Yes	0
OER Commons	8,909	?	12	Yes	8
OER World Map	437	?	50	Yes	11
OpenLearn	All	Yes, All?	16	Yes	4
OpenStax	All	Yes, All	19	Yes	?
Open Textbook Library	All	500+	65	Yes	4

Table 4. Popularity of well-known ROER for teaching and learning.

ROER	Members	Facebook followers	LinkedIn followers	YouTube registered users	Websites pointing to	Links pointing to
Commons (Canvas)	56 users (1,238,425 members of Canvas)	--- (22,400)	--- (13,658)	--- (23,700)	437	4,148
Curriki	656,000	7,562	657	737	5,060	85,195
DOER	3,232 authors	---	---	---	59	195
Klas Cement	281,535 members	12,247	849	666	1,381	36,384
MOM	---	---	---	---	269	1,034
MERLOT	182,845; 4,353 Institutions	2,620	367	561	5,840	219,079
MIT OCW	?	484,696	2,038	2,980,000	33,759	942,270
OASIS	513 Institutions	---	---	---	630	5,185
OER Commons	?	2,955	29	---	7,440	162,853
OER World Map	1,759 registered users	301	---	1	405	5,674
OpenLearn	?	30,968	---	263,000	7,135	113,578
OpenStax	?	25,955	2,747	5,290	3,728	77,880
Open Textbook Library	120; 2,500 faculty	---	26	---	1,741	14,953

Table 5. Usage of well-known ROER for teaching and learning according to SimilarWeb.

ROER	Visits during last six months	By country (%)	By Search; Direct; Refer (%)	Avg Visit Duration	Pages per Visit	Bounce Rate
Commons	91.06K	US: 80%; Australia:3%; Brazil: 3%	17%; 46%; 8%	00:53	1.87	65%
KlasCement	354.64K	Belgium: 85%; Netherlands: 10%; Suriname: 1%	65%; 30%; 2%	04:40	8.40	40%
MERLOT	131.74K	US: 31%; Philippines: 14%; Ghana: 5%	51%; 38%; 9%	01:48	2.02	68%
MIT OCW	4.23M	US: 39%; India: 8%; Canada: 4%; UK: 4%	60%; 29%; 3%	02:44	3.69	57 %
OER Commons	178.63K	US: 71%; Philippines: 6%; Canada: 2%	31%; 50%; 14%	02:59	3.12	57%
OpenLearn	2.56M	UK: 39%;	65%;	03:30	3.92	64%

		US: 14%; Philippines: 5%	28%; 4%			
OpenStax	4.39M	US: 82%; Canada: 2%; Philippines: 2%	20%; 68%; 9%	05:18	3.53	49%
Open Textbook Library	545.71K	US: 57%; Canada: 5%; Australia: 4%	45%; 33%; 20%	01:01	2.04	51%