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Research Article

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Designing Open Informational Ecosystems on the Concept of Open Educational Resources

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Abstract: Open informational ecosystems play a crucial role in fostering open educational resources (OER) and allow new opportunities to share and collaborate in the learning and teaching environment. Such ecosystems containing interoperable infrastructures and open interfaces aim at fulfilling user needs and fostering practices related to the concept of OER and the five user rights (5 R's). To fully embrace this role, those ecosystems need to be designed carefully.

In this paper, we discuss implications for open informational ecosystems to fully comprise the concept of OER and related user needs. We carried out literature reviews to analyse recent aspects of the 5 R's in relation to user behaviour and infrastructures. We will introduce the results from these reviews and illustrate upcoming questions and challenges for the design of an ecosystem respecting the 5 R's conceptual ideas. With our recommendations, we aim at contributing to a better understanding of the concept of OER to improve ecosystem development and implement useful and user-friendly functions.

Keywords: open educational resources; open informational ecosystem, retrieval system; 5 R's.

1 Introduction

To support sharing and creating learning and teaching material like OER commonly amongst teachers, educators and learning designers, new infrastructures and services are developed. Those infrastructures offer searching for resources. More elaborate services even allow for saving, editing and commenting resources and represent user activities and collaboration networks (Santos-Hermosa, Ferran-Ferrer, & Abadal, 2017; Zervas, Alifragkis, & Sampson, 2014). The latter function seems relevant as research shows the potential of networks and communities to foster openness and the use of OER (Cronin, 2017; Weller, 2013). Other studies show that OER search services are not known very well among educators (Heck, Kovalenko, & Rittberger, 2020). While currently designing a meta-search system for higher education in Germany (Kerres, Hölterhof, Scharnberg, & Schröder, 2019; Vagliano, Heck, Kullmann, & Saleh, 2020), we experience that OER services are not well known and used very often by teachers in higher education. We assume one reason for this might lie in the discrepancy between the functionalities of an infrastructure or ecosystem, and the idea to operationalize OER-based activities, as it is described with the 5 R's.

This paper reflects on the concept of OER and its meaning for the development of an open informational ecosystem. It discusses conditions and obstacles for the development of an open informational ecosystem to support the idea of OER. We will introduce the concept of OER based on the 5 R's defined by Wiley (2014), and discuss its operationalization in an open informational ecosystem. We will draw on examples of existing infrastructures as well as user studies and deviate recommendations for the establishment of an ecosystem. With this, we hope to contribute to a better understanding of the idea of OER to improve ecosystem development and implement useful and user-friendly functions to support the conceptual idea of OER. Our research question is: How do open informational ecosystems need to be designed to fully contribute to the concept of OER and fulfil user needs?

Section 2 introduces the concept of OER and the idea of an open informational ecosystem. Section 3 introduces our review method. In section 4 and 5, we discuss the 5 R's and their implications on user activities as well as their

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operationalization in ecosystems. We discuss our results in section 6 and name open research questions, before we summarize our main aspects as recommendations in section 7. Section 8 concludes the paper.

2 Background

2.1 The concept of OER

The idea of OER is to facilitate the access and common creation of learning and teaching material. The concept of OER is embedded in the idea of open education and was prominently introduced in the Cape Town Declaration (CapeTown, 2007). Open educational resources (OER) are educational resources that come with a specific licence. The latter aspect is visible in the just recently published draft from the UNESCO (2019), which states: "Open Educational Resources (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 licence, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others." To make the idea of OER and user rights more comprehensive, OER are commonly described with the rights they come with. It started with the 4 R's (Hilton III, Wiley, Stein, & Johnson, 2010), which mean that users have the right to reuse, revise, remix and redistribute OER. Wiley (2014) added the fifth R - retain - to emphasise the necessity for the right to not only re-use OER, but hold copies of it. Although existing definitions seem to share a common sense, researchers point out differences that might influence the operationalization of the OER idea in practices, i.e. the use of OER by educators. Wiley (2019) argues that the recent UNESCO definition does not include this essential fifth right of retaining OER anymore and claims for re-thinking the UNESCO recommendation. Table 1 shows the definitions of the single rights by Wiley et al. (2014).

The Creative Commons (creativecommons.org) are one of the best known licence models, although other similar licence models exist. According to the CC rights, OER have either the licence CC-0 (public domain), CC-BY (allows 5 R's with citing author) or CC-BY-SA (allows 5 R's with citing author and publishing under same licence). Other CC licences that allow for example reuse, but not for commercial purposes (CC-NC) or do not allow revising and remixing (CC-ND), do not fully comprise the 5 R's. From a user perspective, the most feasible licences are CC-0 and CC-BY, as even the "share alike" rule impairs remixing of OER with different licences.

Table 1: The five user rights (5 R's) by Wiley (2014).

User rights	Definitions
Retain	The right to make, own, and control copies of the content.
Reuse	The right to use the content in a wide range of ways.
Revise	The right to adapt, adjust, modify, or alter the content itself.
Remix	The right to combine the original or revised content with other open content to create something new.
Redistribute	The right to share copies of the original content, your revisions, or your remixes with others.

Throughout the recent years, numerous studies on OER (Bossu, Brown, & Bull, 2014; Boston Consulting Group, 2013; Heck, Peters, Mazarakis, Scherp, & Blümel, 2020) and open textbooks (Seaman & Seaman, 2018) showed that although there is an increase of the use and awareness of OER, a high number of educators still do not use OER, with even fewer creating them. One influencing factor that fosters OER use and creation might be policies (Bossu & Stagg, 2018; Cox & Trotter, 2016). However, among other aspects, Kaatrakoski, Littlejohn, and Hood (2016) still see tensions in practices between an individual's needs and institutional policies.

Another basic problem of OER is that it is primarily content and not an educational model per se (Otto, 2019). This shortage of OER has resulted in intensive debates about the pedagogical implication of using OER in teaching practices. Two influential concepts which have emerged from this debate are open educational practices and open pedagogy. In general, open educational practices can be described as practices that embrace the use and creation of OER and open pedagogies (Albion, Jones, Jones, & Campbell, 2017; Ehlers & Stracke, 2012). However, open educational practices lack a clear single definition. In their review, Cronin and MacLaren (2018) show the historical development and foundational assumptions of concepts of open educational practices. Overall, the use of OER remains the most important core element in the concept and as well dominates many studies, as a recent literature review proves (Bozkurt, Koseoglu, & Singh, 2019). Despite this fact, other recent studies like those from special issues (Bossu & Heck, 2020; Koseoglu, Bozkurt, & Havemann, 2020) take a broader view on the concept and discuss elements like inclusiveness, lifelong learning, open science perspectives and the learners' perspective in open educational practices. This shows the importance of relating the concept of open educational practices

to various contexts, which on the other hand makes it difficult to establish and agree on a single definition.

Studies show that educators are influenced in adopting open educational practices by diverse factors such as the use and creation of OER (Cronin, 2017, compare Wiley, 2015). Conversely, open practices like networking foster the awareness of OER (Cronin, 2017). This paper on ecosystems considers this networking aspect from the perspective of an ecosystem, and will discuss user networking options and behaviour with regard to the 5 R's below. Weller (2013) mentions "network and the learner's connections" with regard to the concept of open pedagogy. For both concepts, open educational practices and open pedagogy, research introduces various definitions and descriptions (Wiley & Hilton III, 2018). To have a more comprehensive concept with regard to the 5 R's, Wiley and Hilton III (2018 p. 135) introduce the new term, "OER-enabled pedagogy", and formulate four criteria to define this concept. Those criteria are formulated in a way to determine open practices in education and to distinguish them from non-open practices, as Wiley and Hilton III (2018) as well complain about an "open washing" of concepts related to OER and open practices.

We will not fully discuss all aspects of the introduced concepts, as this goes beyond the scope of this paper. Instead, we will look at those concepts from the perspective of designing an open informational ecosystem and suggest considering ecosystems and infrastructures within those concepts in further research. In the following, we explain what we mean with an open informational ecosystem.

2.2 Open informational ecosystems

"Information and communication technologies (ICT) provide great potential for effective, equitable and inclusive access to OER and their use, adaptation and redistribution. They can open possibilities for OER to be accessible anytime and anywhere for everyone […]" (UNESCO, 2019). Moreover, the role of technologies is not only to facilitate access and reuse of OER. The concept of OER includes the idea of collaboration among educators, the networks behind the creation of learning material, and the interconnection between resources and educators. "[…] the discussion about open educational resources and open education sometimes oversees the relevance of these intermediary services and how they operate" (Kerres & Heinen, 2015, p. 25). Atenas and Havemann (2014) name the four elements search, share, reuse, and collaborate that an infrastructure shall support. Those elements are represented in the 5 R's introduced above, with collaborate, for example, represented by the activities remix and revise.

We focus on the specialities of such services and speak of open informational ecosystems, i.e. an ecosystem with a network of related infrastructures that provide informational resources like OER, which aims at being open (like providing resources and metadata) to external networks and services (Kerres & Heinen, 2015). If the concept of OER is to be fostered in the best way, we need to think of open educational ecosystems and the question in which way those ecosystems allow for the operationalization of the five OER rights.

In our current research project, we aim at developing a decentralized ecosystem for OER primarily for higher education. Our motivation derives from two major challenges. First, the OER landscape is pre-dominated by stand-alone solutions. In Germany, many universities and single educational institutions started establishing repositories for educators to store their OER and other learning materials. There are some recent networks where universities and other research institutions cooperate to offer a common service. However, educators face the problem of having too much choice. Moreover, the exchange of OER or reference metadata between those services is difficult as it lacks exchange and metadata standards.

Second, the latter challenge lead to another constraint that hinders the concept of OER, which is restricted system access. Stand-alone services are often reserved for a specific user community, like educators at a university. Educators from outside the university often have restricted access. In many cases, they have access to OER, but cannot be part of the OER creation community. Our ecosystem aims at supporting the search, use and distribution of OER from decentralized services and to fully embrace the concept of OER to allow creation and collaboration beyond institutional boundaries (Vagliano et al., 2020). This paper derives from our project and design-thinking processes and discusses the question on the design of open informational ecosystems with regard to the concept of OER and user needs.

3 Method

We base our reflection and discussion on the OER concept and aspects of the implementation of an ecosystem on an extensive literature review and a thematic analysis (Grant & Booth, 2009). The literature search was done by two researcher teams. One team searched for studies on

user behaviour with regard to the 5 R's. The other team searched for implications of the 5 R's for infrastructures.

Our literature search on user behaviour studies was done on three databases (Web of Science Social Science Citation Index, Scopus, ERIC) using the term "open educational resources" in the keyword field to receive international studies in journal articles. At first, we considered studies dealing with the use of OER in higher education. Additionally, cited references in these studies extended literature on this topic. We evaluated these studies in order to give an overview of specific user behaviours associated with the 5 R's as well as missing scientific evidence and further research needs.

In order to discuss the meaning of the 5 R's for ecosystems, we searched for studies that have a focus on infrastructures like OER repositories. Our main databases were Web of Science Social Science Citation Index and ERIC. We searched with a combination of terms in the title (ERIC) and title, keywords and abstract field (Web of Science): ((OER OR "open educational resources" OR "learning object" OR "learning objects") AND (infrastructure* OR architecture* OR repositor*)). We focused on more recent literature with a focus on aspects of infrastructures and OER. Additional literature was considered from references and web search.

4 User perspectives on the concept of OER

4.1 Literature on the 5 R's

This section reports on the literature review on user behaviour and the use of OER in higher education. We focused on the current state and frequency of OER activities, the working methods of teachers using and editing materials, and the general conditions for working with OER, such as material types. Finally, we related these issues to the 5 R's.

The right to **retain** is an understudied perspective of the 5 R's and we found no research dealing with it explicitly. There is little knowledge about how users make copies of a resource, where they store them (e.g. locally on their computer or in a learning management system) and how they manage multiple resources.

In the practical use of OER, the most interesting aspect is how external materials are used or **reused**. It was found that OER is mainly used to integrate new materials into existing courses and thus to extend and supplement them. Additional resources can also serve as self-learning units for students. Furthermore, OER are used as inspiration for teaching and to enhance one's own knowledge (de los Arcos et al., 2015; Lesko, 2013).

The reuse of external materials can be done in a process of validation, review and improvement in the creation of one's own materials. This process includes not only content adjustments but also presentation formats of content (Rodés, Gewerc-Barujel, & Llamas-Nistal, 2019).

Types of material that are frequently (< 40%) used by external sources are presentation slides, images, graphics and video lectures. Most useful for teaching purposes are pictures and videos (< 40%), but also presentation slides and exercises (Lesko, 2013). The creation of materials covers different types, with elements for understanding (tutorials) and for practice being most common (McKerlich, Ives, & McGreal, 2013). While images, video and online textbooks are mainly taken from the Internet, materials like presentations, examination materials, portfolios and course modules are self-created or reused by colleagues (Baas, Admiraal, & van den Berg, 2019).

Revising materials can be considered as the next step of reuse. External materials are transferred without changes as well as adapted for individual context before integrating into one's own materials (Cardoso, Morgado, & Teixeira, 2019; White & Manton, 2011). Hereby changes of various types and sizes can be observed affecting formal aspects (wording, layout, etc.), content (e.g. adding or selecting content), didactic elements (e.g. procedure, arrangement of content and exercises) and technical issues (e.g. use of tools).

Whereas formal changes, such as linguistic adaptations, predominate (Beaven, 2018), content-related adjustments affect deleting and arranging of content. Specifically, with open textbooks, less content is added and hardly ever remixed (Hilton III, Lutz, & Wiley, 2012).

According to the **remix** problem, there is little empirical evidence that OER components involving processing and mixing of materials are realised (Wiley, Bliss, & McEwen, 2014). Other studies, in turn, see the OER cycle anchored in teachers' practice (Beaven, 2018). Thus, it remains open to what extent remixing takes place and is not answered within empirical studies.

There is little evidence of **redistribute** materials which means sharing materials that have been modified (Petrides, Nguyen, Kargliani, & Jimes, 2008). Sharing of self-created materials is also low (Cardoso et al., 2019). Sharing takes place in public repositories (Beaven, 2018; Cardoso et al., 2019), mostly within a community without a licence (Beaven, 2018), so that invisible use and dark reuse of materials in private environments has been demonstrated. Main target groups are students and

Table 2: User rights based on the 5 R and their implications.

User rights	Associated activities	Practical implications for use of OER	Scientific findings in the research literature	Further research needs
Retain	Copy, download, save a copy of the content locally or in a cloud or bookmark a link with the goal to have it permanently available.	Copy external materials into one's own learning management system or working environment.	No studies to date.	How are resources saved?
Reuse	Use the work verbatim, just exactly as you found it. Copying, displaying, performing, and making other uses of a work just as you found it; e.g. in a class, in a study group, on a website, in a video	Copy/Use external materials into one's own working environment/ learning management system. Division of materials into course units to enable individual adoption.	Evidence of the integration of external materials into other individuals materials with and without improvements	What are established practices for integrating materials?
Revise	Modify or transform (e.g. translate content into another language or formats) material so that it better fits the own needs	Availability of open file formats to allow editing. Course units must allow customization to transfer them into other educational contexts.	Adjustment of external materials to individual contexts. Formal changes occur the most frequently. Content changes include deletion and arrangement of content.	What needs do teachers have when revising different types of material?
Remix	Combine the (verbatim or modified) work with other works to better meet the individual needs. Creating a recomposition (assembles or incorporates the content) of several works.	Division of materials into course units to enable individual transfer and combination.	The available data draws different conclusions that either shows not remix activities or the lack thereof.	How and to what extent are remix activities in fact applied?
Redistribute	Share the verbatim work, the revised work, or the remixed work with others (e.g. give a copy of the own version to a friend)	Link to externally stored material or references. Establishing a culture of sharing and facilitating reuse.	The sharing of created and modified materials takes place mainly among colleagues and rarely in public.	For what reasons are resources not shared again?

colleagues (Beaven, 2018). Thus, the question of where and with whom materials are shared has been adequately addressed in the literature.

The evaluated studies provide basic information on the user behaviour of teachers, particularly with regard to the elements "reuse", "revise" and "redistribute". Nevertheless, further information on procedures of editing and remixing materials is necessary to gain a more detailed insights into behaviour patterns and the needs of teachers.

4.2 Implications of the 5 R's

Based on the literature, we derive associated activities that are common in the use of OER, and relate them to practical implications. Table 2 summarizes the elements and in addition shows further research needs in relation to the 5 R's that we suggest investigating.

5 Infrastructural perspectives on the 5 R's

5.1 Literature on OER ecosystems

There is a large variety of OER infrastructures, for example repositories (containing OER), referatories (refer to OER, like bookmarking services), learning platforms (compare Zervas et al., 2014), and digital libraries (Ahammad, 2019).

We are not aware of a clear definition and distinction between different types of OER infrastructures and their respective goals. This fact makes it difficult to compare best practices with regard to user needs and behaviour on the 5 R's. Studies show that even users sometimes feel insecure about goals and functions of a certain website (Heck, Kovalenko, & Rittberger, 2020). This aspect becomes pretty clear when looking at the service designs. Figure 1 shows two German examples: ZOERR addresses university

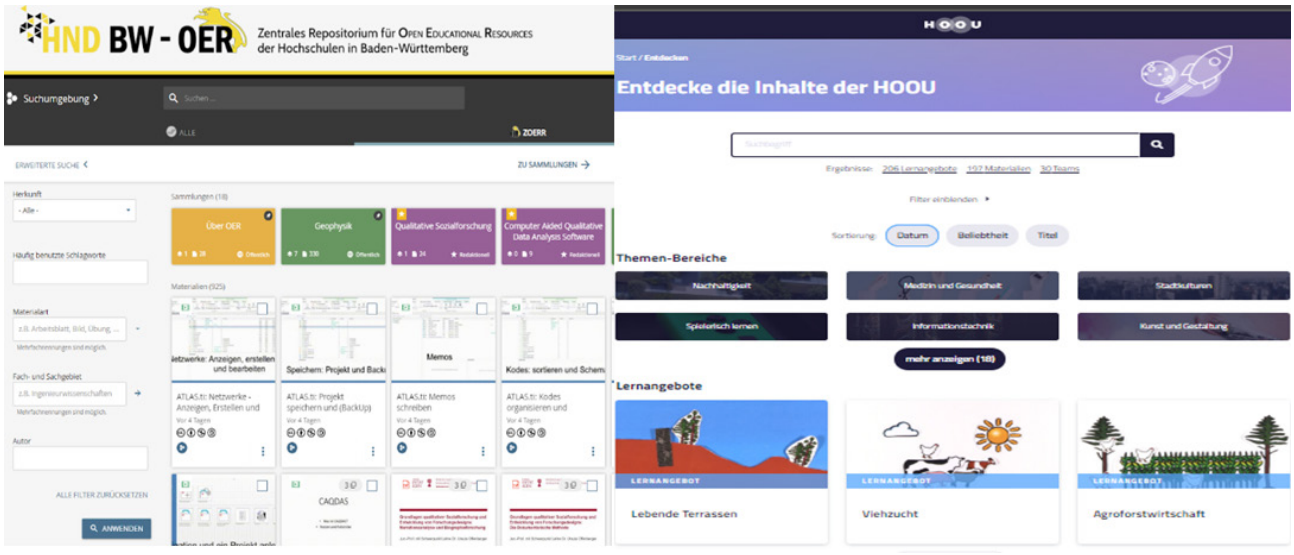

Figure 1: The ZOERR repository (https://www.oerbw.de/edu-sharing/components/search, left) and the HOOU service (https://www.hoou.de/discover?sort=-published_at, right).

members and looks like a general search system with a search entry field at the very top and filters on the left hand side. HOOU addresses the public in general and is rather intended as a learning platform. A classification would help to better distinguish between different goals of services and their level of openness, for example the number of open and closed resources (Amiel & Soares, 2016).

Research suggests diverse quality frameworks for OER infrastructures, either with a specific focus like metadata improvement (Palavitsinis, Manouselis, & Sanchez-Alonso, 2014; Vidal-Castro, Segura Navarrete, Menendez-Dominguez, & Martinez-Araneda, 2017) or with a broader perspective (Atenas & Havemann, 2014; Clements, Pawlowski, & Manouselis, 2015). Based on a literature review, Atenas and Havemann (2014) introduce quality indicators and relate them to the four elements to be supported by the infrastructure: search, share, reuse, and collaborate. Further research needs to specify how to measure those indicators and how to describe their contribution to the 5 R activities and user needs. Other frameworks as well focus on quality assurance studies (Clements et al., 2015). As mentioned above, social user interaction (like rating or commenting) seems to be important to foster collaboration. The authors describe this element as part of the quality assurance process within an infrastructure, among instruments like peer reviewing and recommendations. However, a main challenge with most of those instruments is the establishment of a critical mass to guarantee effective quality assurance (Clements et al., 2015). Zervas et al. (2014) stresses that OER infrastructure design mainly focuses on the search of OER, not on teachers' and learners' interactions within infrastructures.

The discussions on quality frameworks are relevant to improve the interoperability and interexchange between OER infrastructures in an open informational ecosystem. However, their focus lies on quality measurements, and hardly discuses questions related to the representation of the 5 R activities and user practices.

The reuse dimension of the 5 R's is part of a study by Santos-Hermosa et al. (2017). The authors provide an overview of OER repositories in higher education at an international level. Their aim was to analyse a series of educational indicators to determine whether OER repositories meet the specific needs of educators, and to clarify the understanding of the reuse of OER. They explored 110 repositories and analysed them using a set of indicators by three core evaluation dimensions: general factors, drivers for OER reuse, and educational aspects.

As the most important feature to promote reuse in mixed repositories (repositories containing resources that have open licences or copyright law and commercial licences), Santos-Hermosa et al. (2017) identified open licences and social networks. Features of intentionality, versioning and quality are less important, and for granularity and open formats they found less evidence. "This suggests that repositories focus more specifically on OA licensing for OER and on taking care of or facilitating the creation of communities of users, who, in turn, could offer additional bottom-up quality criteria for deposited content" (Santos-Hermosa et al., 2017, 121). For OER-exclusive repositories, they found that open

licensing remained important, social networks increased considerably, but quality and granularity became more important as well. "Therefore, OER-exclusive repositories include a wider range of features, and use them more intensively, to facilitate the reuse of their resources" (Santos-Hermosa et al., 2017, p. 121). The authors give an explanation on functional elements that foster the (re) use of OER. Our next step in section 5.2 is to conceptualise technical implications for the dimensions of all the 5 R's.

5.2 Implications for ecosystems

To incorporate the concept of OER in our ecosystem, we first need to be aware of the technical implementations that are needed to fulfil the implications of the 5 R's. Therefore, we assigned possible system functions mentioned in current studies and derived from existing services to the five rights (Table 3). We differ between obligatory and supporting functions. We see obligatory functions as crucial functions that need to be implemented to represent the 5 R's. Supporting functions are not necessary, but they increase the potential of single rights and improve the usability of a service. In some cases, implementing or leaving out functions depend on the intended goals of a service. We leave this as aspects to consider (Table 3) and will discuss those aspects in the following.

5.2.1 Functions serving the concept of OER

As the concept of OER is described by the five user rights, it is obvious that an ecosystem needs to clearly provide licence information for its contained learning resources. We did not add this function into table 3. Licences are obligatory to provide all dimensions of the 5'Rs. Features of user interactions such as the opportunity to comment, rate OER, share thoughts in a wiki etc., are also affecting all five user right dimensions. Furthermore, licences and user interactions are not only functionalities in technical implementations. Licences focus on copyright law. User interactions give an indication of social interaction and cultures of communication that foster open practices (Cronin, 2017).

Retain refers to the ability to save OER for one's own purposes. The type of storage can take two forms. On the one hand, OER can be downloaded from an OER repository and saved on one's own data carriers for further use. For this purpose, the repository must provide a download function. On the other hand, personal collections of OER can be created via bookmarking or tagging within an OER repository or referatory. In this case, the user must be able to create a personal user account and provided storage space on behalf the service (compare Cohen, Reisman, & Sperling, 2015).

User accounts can thus be a helpful means of managing personal OER collections and offer added value for users. However, they can also be viewed critically in the context of open ecosystems as those ecosystems only allow using their full service to registered users. If the creation of a user account is a prerequisite for the use of an OER service, this acts as a mechanism of closure and might negatively affect openness, as the user has to pay for access to OER with personal information (Kerres & Heinen, 2015, p. 30). In order to keep possible barriers for the usage of open ecosystems as small as possible, it makes sense to offer both types of use (with and without a user account).

For references to OER provided by referatories, it must be noted that there is no guarantee that referenced OER can actually be found at the external storage location. Unique identifiers can help here, as they allow the re-finding of an OER more easily.

The first requirement of **reuse** is the ability to find suitable OER. A user-friendly search mask and an intelligent ranking algorithm are just as necessary for this, as is a meaningful description of the external and content-related features of the OER via proper metadata containing educational fields like learning purpose or learning level. Although the Learning Object Metadata standard (https://standards.ieee.org/standard/1484_12_1-2002.html) and the Learning Resource Metadata Initiative (https://www.dublincore.org/specifications/lrmi/1.1/) provide a means for the uniform description of learning resources, not all repositories make use of these possibilities (compare Santos-Hermosa et al., 2017). This makes it difficult to easily exchange metadata between different repositories, a crucial function for a decentralized ecosystem that wants to offer OER stored in different infrastructures. The situation is even more complex with regard to the vocabularies used, i.e. determined values to fill in standard metadata fields. So far, generally accepted vocabularies are missing for higher education. Standards would allow for better interoperability between ecosystems and the common sharing of OER. Additionally appropriate and high quality metadata are an important prerequisite for useful search functions like search filters. Search filters can significantly improve search results and make it much easier for users to find suitable OER.

The allocation of appropriate metadata is not trivial and is time-consuming. Users are not willing to invest time for this task. In addition, most also lack the knowledge for a satisfactory description of their OER with metadata.

Table 3: Implications of the 5 R's for an open informational ecosystem.

User rights	Obligatory functions	Supporting functions	Technical implementations	Further aspects to consider
Retain	Download for OER	Download metadata; Unique identifier for OER; Bookmarking and tagging own OER collections of intern or extern links	Download button for OER and/or metadata (in divers formats); User account if service wants to offer individual OER collections	Sustainability of reference, access in referatory or with bookmarking function; Unique identifier to re-find OER
Reuse	Using a proper metadata standard; Search interface; Ranking of search results	Granularity (apparent for formats and context); Search filters; Save search; OER web (pre-)view; Social visibility (of user activity network)	Showing OER relations to other resources and disciplines; results display; display metadata; User accounts to display OER and keywords of other users	Showing context when OER has different versions
Revise	A: Download and upload for OER OR B: Web editor or commenting option	Versioning for OER; Open formats	A: Download and upload button or web editor; unique identifier for OER supports identification A solution for versioning problem have to be technically implemented or recommended within the service	Various (open) formats have to be attended; Anonymity of users; Versioning can influence search
Remix	A: Download and upload for OER OR B: Web editor or commenting option	Unique identifier for OER; OER collection	A: Download and upload button or web editor; unique identifier for OER supports identification	Problem of mixing incompatible licence types affects legal aspect
Redistribute	Upload for new OER or add new reference; Educational metadata standard	Unique identifier for OER; Describe OER with determined vocabulary or own keywords	Upload button for new OER file or save function for new reference to make redistributed OER usable	Problem of unstructured vocabulary (mixed terms) makes sophisticated use of metadata difficult

Therefore, a procedure and correspondingly qualified personnel is required for the metadata allocation to take over. This makes the operation of an OER repository very complex. Appropriate long-term financial resources must be made available for this purpose. Automated processes are possible for some metadata, like title, author and format (Pdf, video) extraction. However, metadata that is crucial for an educator to decide whether a resource is personally relevant, like subject/discipline, educational level and granularity (Keck & Heck, 2019) cannot yet be generated automatically.

Granularity focuses on the complexity of a learning resource and is a useful supporting function in open ecosystems. A whole course, for example, with a high level of granularity can cover the learning content of an extensive curriculum with many different learning objectives and combine different materials (texts, graphics, tables, exercises, learning controls, etc.). In contrast, simple learning materials have a far lower granularity, as they usually relate to only one learning objective, but can be used by a teacher within a specific learning setting and can be processed by the learner in a reasonable amount of time (Kerres & Heinen, 2015, p. 27). For teachers as well for learners it is very useful to know about the granularity of an OER. Information on how resources are related and in which context they are used supplement information on granularity.

Further supporting functions are the possibility of saving search queries and search results and the possibility of pre-viewing OER in the browser. Additionally, the

integration of social media elements foster the sharing of OER between creators and learners and can help to increase the social visibility of actors. In this way, the OER created by actors and, for example, the keywords used by them can be displayed and viewed by others.

Revising is a central characteristic of OER. From a technical point of view, this requires a download in combination with an upload option. Alternatively, an authoring environment/web editor can be offered that enables actors to edit OER directly on the platform. The latter would solve the technical challenges to detect uniquely allocate revised OER to their original. If the first option is preferred, a unique identifier would facilitate the allocation, but not guarantee it.

Beside technical challenges with the revise activity, this user right comes up with another issue. In general, every slight change of content produces a new version of that OER. The question arises, whether changes produce a new version or a complete new OER. Thus, versioning needs to be customized to the character and idea of OER. Users, however, want the opportunity to understand the further development and usage of their self-created OER. A procedure to create and show versions of an OER and their individual context is therefore useful. Search systems suffer from similarly OER (e.g. a recorded lecture repeated each year) that appear in search results several times. They might cause a distrust in the user's perception of the effectiveness of the search system.

In order to be able to edit OER easily and quickly, file formats are crucial. For this reason, OER should be available in an open format whenever possible. Alternatively, it makes sense to offer converters that turn non-editable formats into editable ones or a web editor for direct online revisions as stated above.

Remixing OER requires a combination of a download and upload function or alternatively an authoring environment/web editor. It is desirable to assign unique identifiers for each remixed OER. In the course of remixing OER, the question of the ability to combine open licences comes to the fore. Applying the 5 R's, strong OER need to have either one of the three CC licences, CC-0, CC-BY or CC-BY-SA, or a similar licence allowing the same rights. Other CC licences, for example, are too restrictive and hurt the 5 R principles. With regard to licences users need to be careful to distinguish their retrieved material according to their rights to use it. At this point, integrated technical aids like the Common Creative Mixer (ccmixer.edu-sharing.org) can be useful that show the user whether selected OER can be remixed.

However, research shows that many OER repositories contain material with a variety of other licences. One the one hand, this fact allows ecosystems to expand their database and recall, so users are able to find more material. With the weakest licence, a user could still cite material, even if further rights are denied. On the other hand, these resources do not support the concept of OER. Research found that OER-exclusive repositories foster reuse of OER (Santos-Hermosa et al., 2017). It is an open question, whether target groups in higher education either prefer ecosystems with a high number of learning resources, or with a smaller number of OER only.

For **redistributing** OER, an upload function (repository) or a possibility to add new references to a collection (referatory) is essential. When it comes to a new OER or a new version of one or more OER after editing or remixing, functions for the orderly allocation of metadata also play a role. At this point, the system must again support the use of suitable metadata standards and vocabulary, as already noted in the reuse section.

6 Discussion

The literature review on user perspectives shows that the ideas of the 5 R's are well understood and investigated. We identified research gaps like studies on how users retain learning resources and if they have a need for infrastructural support with this activity. We formulated open questions (Table 1) for further research on any of the 5 R's. Questions relate to specific practices of users (like "What are established practices for integrating materials?), and reasons for not applying the rights ("For what reasons are resources not shared again?").

Answers to those questions are relevant for the design of the ecosystem. For example, the question "How and to what extent are remix activities in fact applied?" would allow for a decision based on user preferences on the two design options – either offer a download and upload function or alternatively an authoring environment/web editor. From the infrastructural perspective, questions on how to support and track remix activities arise. One support function of an infrastructure could be to automatically prevent the remixing of incompatible licence types.

A crucial question arising from the technical implications is the ecosystem's impact on user benefits and further positive effects on user experiences like enthusiasm and motivation to engage in the 5 R activities. For example, research argues that "personal spaces" (Cohen et al., 2015) like bookmarking and storage functions as well as visible user networks (Cronin, 2017; Santos-Hermosa et al., 2017) positively influence user activities. The question on user

impact is similar to arguments by Wiley and Hilton III (2018), who suggest further research on OER-enabled pedagogy. We argue to include a technical and usability perspective that considers teachers and learners as actors within an open informational ecosystem.

This leads to another aspect, which is the proof of 5 R activities within an ecosystem. If an ecosystem supports user engagement while making community activities and networks visible, 5 R activities need to be monitored and stored within the system in some way. Therefore, the technical design needs to be adapted and expanded (Table 3). This comes with new challenges. For example, we still lack a solution for OER versioning – not only technically, but we need to discuss the meaning of OER versioning and the relevance for learners and teachers as well as pedagogical aspects.

In addition, Wiley and Hilton III (2018) claim that we still do not know how to measure the impact of open pedagogy as it is not yet defined properly and "we cannot specify what we are evaluating" (p. 135). If user activities like downloading and remixing OER are measured in an ecosystem, we need to discuss what those activities really tell us and what we measure. On the one hand, OER-based user activity indicators can show an ecosystem's impact and success of fostering OER. Having this proof might guarantee further technical development and the sustainable continuation of the ecosystem. Therefore, many infrastructure providers see a need to track user activities. On the other hand, those indicators might not properly represent user practices on the 5 R's. For example, users do not revise material very often (see 4.1). It is an open question whether they would be willing to additionally indicate revisions to an OER, or use an online editor that automatically monitors revisions. Either one of these options is needed by a system to track revising activities.

7 Recommendations

The discussion on the concept of OER based on the 5 R's and its practical implication for users and open informational ecosystems was derived from our project on an OER meta-search engine and the challenges we face during the design and conceptualization. In addition to open research questions and technical challenges (Table 2 and Table 3), we would like to summarize our main findings as recommendations for further research and ecosystem development.

1. Design ecosystems with regard to open practice concepts: The provision of OER is a first, crucial step to enable open educational practices. Due to the diversity of meanings of open educational practices within diverse contexts, those practices have to be understood and analysed in three dimensions a) as conglomeration of models how to use OER and how to do learning and teaching (compare Otto (2019), b) as a praxeological term analysing "doings and sayings" (Schatzki, 2002, p. 87) in learning, teaching, and doing OER (compare Bellinger and Mayrberger (2019), and c) as an overall concept with pedagogical implications to open up education. Open informational ecosystems prepare networks of learners and teachers, but do not yet figure out and illustrate pedagogical models. Wiley and Hilton III (2018) suggest "OER-enabled pedagogy", which can be a key concept between OER and open educational practices. We argue considering the design of open informational ecosystems with respect to those conceptual discussions and frameworks.
2. Consider a user-centred design: Ecosystem's with their technical implementations do need to consider the concept of OER described with the 5 R's as they describe specific user activities. OER-based user activities are embedded in user practices within learning and teaching environments. In addition to our first recommendation, we recommend designing an ecosystem according not only to the 5 R practices, but also to user behaviour within their different ecosystems, e.g. school teaching, higher education or vocational education.
3. Consider OER monitoring with care: If we want to keep track of OER-based user activities like revising and remixing, we need to have specific technical implementations. Making activities visible for users might foster more user engagement. However, technical implementations for keeping track of activities might not be beneficial for users with respect to learning and teaching practices. The conflict between OER monitoring for proving an ecosystem's benefit and the decision not to keep track of all user activities to consider user practices, needs to be carefully considered by designers. Moreover, we need to become aware of what OER monitoring is able to measure and what those measurements tell us about learning and teaching benefits. Here, more research is needed.

4. Define a clear purpose and system classification: OER services are manifold, but we lack a classification of different service types. This would help users find their way through diverse OER services. Moreover, defining a clear purpose is of importance for the technical design. For example, higher education teachers use open access research articles or open research data as learning resources. If an OER ecosystem contains a large number of scientific papers and data, it would serve the quantity aspect of available learning resources. However, resources explicitly designed for learning and teaching lose visibility and are harder to find. Users looking for educational resources might become frustrated when finding a large number of research material, which could also be found in digital libraries or dedicated repositories for this purpose. The conceptual boundary between OER ecosystems and digital libraries vanishes and users might question the relevance of both systems.
5. Be aware of target groups: OER might not focus on either educators or learners, they are intended to serve both target groups. Due to this broad orientation, it is difficult to design OER ecosystems precisely to meet the needs of all possible users in the best way. For example, OER ecosystems often do not offer opportunities for interchange and collaboration between OER creators and learners. Currently, many OER ecosystems are mainly a kind of digital library for educators, others resemble a virtual learning platform. Here, more research is needed to investigate a) in which way an OER ecosystem can serve both target groups, and b) which functions educators and learners prefer.

8 Conclusion

We argue that open informational ecosystems are a crucial element for the adoption of OER and related practices within broader concepts of open educational practices and open pedagogy. Therefore, the concept of OER and the five user rights need to be considered during the design of such ecosystems. We introduced user behaviour patterns of the 5 R and their implications for ecosystems. Our reviews show research gaps with regard to user behaviour and the technical implementation of the 5 R's and formulated open questions. From those results and discussion, we formulated critical aspects to consider for the design of an OER ecosystem.

Research on ecosystems and digital infrastructures focus on technical implications, quality and the provision of OER. Concepts like open educational practices and open pedagogy focus in pedagogical implications and student-educator practices. The recent work by Wiley and Hilton III (2018) aims at offering a concept, OER-enabled pedagogy, to better determine what we mean with open practices with regard to OER. This step will help to better understand our idea of open practices and to measure their impact in future research. In addition, we suggest including open informational ecosystems within future concepts to better understand the influence of infrastructures and tools on open practices and to be able to improve the design and implementation of such ecosystems according to intended learning and teaching goals. This, as well, means including ecosystems in current quality frameworks like the one suggested by Stracke (2019) and consider the 5 R in recent frameworks (Atenas & Havemann, 2014; Clements et al., 2015). Our future research will investigate quality criteria for ecosystems while considering concepts of openness in education and the user rights described with the 5 R's.

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