Daniel Otto · Gianna Scharnberg ·
Michael Kerres ·
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RESEARCH

Distributed Learning Ecosystems

Concepts, Resources, and Repositories

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Contents

Resources

Repositories

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Introduction: Distributed Learning Ecosystems. Concepts, Resources, and Repositories

Daniel Otto, Gianna Scharnberg, Michael Kerres and Olaf Zawacki-Richter

1 Introduction

For a long time, teaching and learning were understood as activities tied to a particular sense of place. Although various concepts had emerged, such as distance learning, e-learning, blended learning, and online learning, these mainly occurred in academic debates but were widely absent in pedagogical practices in higher education.

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The incisive developments during the COVID-19 pandemic have made the importance of online learning for education in the digital age evident, and it is unlikely that this wheel will be turned back in the foreseeable future (Brown, 2021). First experiences show, for instance, that online learning can support the development of digital education and the practices of student engagement (Gourlay et al., 2021) and can lead to an openness towards learning innovation that was not present before the COVID-19 pandemic (Rapanta et al., 2021). However, as the term "online" learning implies, the internet has played and will play a key role in developing and distributing new forms of teaching and learning.

What is remarkable from an educational media perspective is that efforts and studies primarily treat the internet as an amorphous space where tools and services can be provided and delivered. Consequently, one rarely encounters the question of how the learning space itself has to be designed on the internet to enable and support different notions of teaching and learning. The authors of this book are convinced that this will be one of the crucial questions of the following decades.

From our perspective, the only appropriate answer is that the notion of open education must guide all design approaches for the internet to enable education as a public good (Otto & Kerres, 2021). As proof of concept, this book presents the idea of designing and conveying education on the internet as a mesh of Distributed Learning Ecosystems (DLE).

The DLE concept was developed in the research project "Digital Educational Architectures. Open Learning Resources in Distributed Learning Infrastructures" (EduArc), funded by the Federal Ministry of Education and Research (BMBF) in Germany from 2018–2022. For this undertaking, an interdisciplinary project consortium was created, consisting of the University Duisburg-Essen, the University of Oldenburg, the Leibniz Institute for Research and Information in Education in Frankfurt/Main (DIPF), and the Leibniz Information Centre for Economics (ZBW), in order to address the different technical, pedagogical, and organisational aspects. The consortium developed a design concept for distributed learning infrastructures with which digital educational resources can be provided in a federated manner. For this, it explored the technical, instructional, and organisational conditions for the success of an educational architecture that is based on networking higher education institutions and the interaction of state, public, and private actors. The project mainly focused on the challenges that arise when distributing Open Educational Resources (OER) in an "informationally open ecosystem" (Kerres & Heinen, 2015), particularly the provision and access to repositories. Furthermore, it explored possibilities of linking via metadata, dealing with different versions of the material, and the possible quality mechanisms in this context. Finally, the project also strove to connect to existing country-specific, national, European, and international developments.

The basic concept of a learning ecosystem reflects the observation that different elements interact and influence each other in today's learning processes. For higher education institutions, a learning ecosystem comprises all services, resources, and environments within the institution that enable or support learning processes.

The main argument found in the book is that, although these learning ecosystems are increasingly established in higher education institutions, there is still a gap regarding their permeability and interconnectedness. Consequently, the book intends to close this gap by presenting the concept of DLE. The authors of the different chapters are guided by the aim of addressing the pitfalls that exist on the way to achieving this goal. In order to cover the crucial aspects, the book offers an interdisciplinary perspective that addresses the three critical aspects: concepts, resources, and repositories. To approach these aspects comprehensively, we invited a range of acknowledged researchers and practitioners to complement the research done within the project and beyond.

2 Structure of this book

Section I: Concepts

The book's first section covers the core conceptional elements that need consideration before thinking about DLE.

Otto and Kerres start by introducing and defining the basic concept of DLE. Then, they demonstrate that the internet is increasingly becoming the space where learning takes place and that DLE can serve as a concept for establishing a link between decentralised learning ecosystems (consisting of content repositories and educational resources) that exist in the higher education landscape. With reference to the other chapters in the book, their chapter highlights challenges and solutions on the road to DLE.

The second chapter by Bozkurt and Stracke introduces openness as the philosophical basis of DLE. The authors show that openness has emerged as one central topic of interest due to the wideness of its scope and the opportunities it offers. The impact the digital transformation in terms of online technologies has had on openness in education is explained, and the characteristics of ecosystems and learning ecologies are presented from a socio-environmental perspective. The authors conclude that if practised through DLE, openness in education can unfold its full potential.

Repositories play an important part for DLE as they serve as the dots that need to be connected. Santos-Hermosa, in her chapter, provides a comprehensive analysis of the role of institutional repositories in higher education. She critically assesses their purpose and level of openness. The latter is crucial for allowing learners and teachers to deposit their educational resources for open sharing and use in teaching and learning processes. It is stimulating to read her suggestions on advancing from open content and OER to Open Educational Practices (OEP) and from OAI-PHM (Open Archives Initiative Protocol for Metadata Harvesting) protocol interoperability to Linked Data and Open Informational Ecosystems. Lastly, she presents several ongoing initiatives that need to be considered.

Online courses are an essential element in DLE. However, an online course is a concept that is not well defined. Stracke et al., in their chapter, present a typology of (open) online courses and their dimensions, characteristics, and relationships with DLE, OER, and Massive Open Online Courses (MOOCs). The authors elaborate on the key terms and conduct a literature review, confirming the absence of a typology framework for online courses. Consequently, they analyse and compare dimensions and categories of online courses from diverse sources and develop a framework proposal for typologies of online courses (TOC) with eight dimensions that can support designers in the design process, quality development, and evaluation of online courses. Furthermore, the framework enables learners to differentiate online courses according to the dimensions of these courses in comparison with their own preferences and demands. Finally, the authors present some thoughts on how OER and MOOCs can contribute to DLE and the general need for (equitable and collaborative) open education.

Open textbooks are another concept that has gained prominence in the context of open education. Studies with open textbooks have repeatedly shown that they can reduce educational material costs while achieving the same learning outcomes as conventional textbooks (Hilton, 2016). Pitt, in her chapter, takes a closer look at open textbooks, which she defines as complete course books available on open licenses. They have been particularly successful in facilitating widespread use of OER in some regions, such as North America. The chapter surveys the current extent and future potential use of open textbooks in higher education. Notably, it examines how open textbooks are used to address challenges in higher education and provide opportunities for connecting and enabling institutional and extra-institutional communities. Pitt finds that while open textbook ecosystems are well developed in some countries, the role of open textbooks is still emergent elsewhere. She provides key lessons learned from more mature ecosystems as well as those where open textbook use remains limited.

Section II: Resources

There can be no doubt that OER provide a nucleus of open education and, therefore, have to be considered in any learning ecosystem design. However, especially in empirical research, there is still limited knowledge about how OER are used or should be used in education (Otto et al., 2021). The second chapter sheds light on the issue by providing innovative chapters on the diverse aspects necessary for designing and connecting DLE.

Schuwer and Baas start with a chapter on the reuse of OER, a much-needed perspective in the debate on OER. Too often, the focus is on the lack of awareness of OER or barriers to their use (Koseoglu & Bozkurt, 2018; Otto, 2021b). The authors find that the extent of reusing OER is still limited. One problem here is that the measurement of actual reuse is difficult. As a result, much of the reuse remains invisible or happens under the radar, often labelled as dark reuse (Beaven, 2018). The authors develop a process model for the practical reuse of OER to determine which support and skills are needed. This model differentiates between two scenarios: an educator-centred and a student-centred one. However, to maximise the impact, the authors conclude that support structures and skill programmes should be directed both at educators and students.

The aspect of quality has been one central controversy in OER discussions (Yuan & Recker, 2015). It is certainly debatable whether and to what extent the idea of openness can be reconciled with a demand for quality standards. Lübben et al., in their chapter, draw on this debate and stress that primarily due to their dynamic development process, OER pose a unique challenge regarding quality assurance. They argue that although many approaches to developing procedures for quality assurance exist, there is still a lack of suitable instruments to measure the quality of OER. An empirical validation of the German version of a quality instrument is presented in their chapter. The validation included the analysis of interrater reliabilities, internal consistencies, and an estimation of construct validity operationalised as convergent validity with the MERLOT Peer Reviewer Report Form. This provides a basis for the authors to discuss the importance of quality assurance of OER within DLE. They argue that to ensure the quality of OER, three conditions must be met: First, there must be practicable procedures for measuring quality. Second, reliable and valid instruments for measuring quality must be used. Third, the results of any quality measurement must be communicated back to OER users.

How can we incentivise teachers to engage in OER activities? Unfortunately, answers to this question are rarely addressed in OER studies (Otto, 2021a). In their chapter, Schön et al. present the case of the “Forum Neue Medien in der Lehre Austria” (fnma), responsible for developing and introducing a procedure to ascertain OER competencies and OER activities in higher education. The aim is to develop and implement an operative and recognised procedure that sustainably promotes and makes visible OER activities and OER competencies at Austria's higher education institutions. The authors deliver an operational plan, present first results, and discuss how the competence framework is compatible with other existing frameworks.

The section concludes with a much-needed chapter on the debate on OER. With "Future directions in OER", Kimmons and Irvine reflect on OER and why we should avoid technocentric narratives of OER as having effects in themselves. Instead, we must explore the opportunities provided by open technologies and resources to rethink what learning is all about, rethink education, and actively work to reshape our institutions in accordance with possible futures. This rethinking and reshaping is not only limited to how we understand the impact of OER, but also how educators can more feasibly create and use OER and how we make a better and more equitable world. The chapter also explores some of the emerging possibilities offered by OER to rethink how we approached education in the past and how we can use OER to move toward futures that allow for more sustainable generosity.

Section III: Repositories

Repositories are constitutional parts of federated open educational infrastructures. While Santors-Hermosa provided a first glance with her chapter, the chapters in this section show and address the different challenges that arise in the process of designing and connecting different repositories.

Hiebl et al. build on the discussion in the last section and combine it with Open Educational Practices (OEP), which have become a powerful concept in discussing the pedagogical implications of OER (Cronin & MacLaren, 2018). The sharing and collaborative creation of OER are at the core of such practices. Digital infrastructures provide environments for these kinds of practices and reflect ideas and implications of OEP through the functionalities they offer and can, therefore, be regarded as key drivers. Since a shared understanding of OEP has yet to be defined, this chapter shows the relationship between open practices and digital infrastructures and reveals challenges for designing digital infrastructures that foster OEP.

Learning Management Systems (LMS) are typically the place where teachers provide learning material, and learners access it. Therefore, providing access to OER repositories for both groups through LMS is desirable from a pedagogical perspective. An informational perspective is needed to accomplish this goal. In their chapter, Abdel-Qader et al. outline the process of connecting OER repositories using the Learning Object Metadata (LOM) standard step by step as simply as possible. Detailed specifications and requirements for connecting different OER repositories using the LOM standard are considered from a technical point of view. The authors define the used technical terms and show how the process works at the back end. More specifically, for each stage of connecting repositories, from harvesting the metadata from those repositories to storing the processed data in files ready to be used in the front end, they describe the functional requirements and technologies needed and how the process works. Their idea is to allow non-technical staff to replicate such a process or stages of it. They round off their hands-on approach by giving examples of tools that may help in the process of harvesting data from the web. Some of these tools are visual and do not require any programming skills.

If we follow the idea of OER becoming increasingly available in different repositories, we might wonder how we can distinguish the different versions of a resource. Moreover, how can we track the changes that were made to a resource? Schroeder, in her chapter, addresses this crucial challenge of OER in DLE, taking on board the various initiatives worldwide that are currently investigating technical developments for finding and sharing OER in higher education. She finds that engaging in OER can result in new versions of a resource, and further developments by other users can lead to derivatives. Therefore, managing these versions in terms of tracking changes and learning about new versions available is not only an issue for developing OER repositories. It also facilitates the interconnectedness of repositories, which can improve the discoverability of OER in DLE. Consequently, she discusses use cases of OER in the context of version management and presents approaches to managing educational material in DLE, resulting in a concept of version management for OER.

While more OER become available, these are often not discoverable for teachers and learners (Cortinovis et al., 2019). One reason for this is that they are not findable to potential users because they lack any or adequate metadata. Menzel dedicates his chapter to this topic by first introducing the recognised FAIR principles (improve Findability, Accessibility, Interoperability, and Reuse of digital assets) necessary to describe educational material through meaningful metadata. However, there are conflicting demands to complying with them. On the one hand, the educational resources should be described in as much detail as possible for accurately fitting search results. On the other hand, only strictly necessary information should be obligatory to keep the obstacles for authors as low as possible. Operators of OER repositories from several federal states in Germany (HOOU, OERNDS, ORCA.nrw, VCRP, VHB, ZOERR) have developed a metadata profile focussing on OER in the context of higher education. Menzel describes the decision process and specific choices that were made to reach this goal.

Last but not least, in this section, Ahamd et al. deal with another emerging topic, learning analytics. Learning analytics has received increasing attention among the educational research community (Chiappe & Rodríguez, 2017). Following Ahamd et al., learning analytics consists of various steps that include data harvesting, storing, cleaning, anonymisation, mining, analysis, and visualisation to make educators' vast amount of educational data comprehensible and ethically utilisable. Instructors can then use the advantages that learning analytics brings to benefit education. These include the potential to increase learning experiences and reduce dropout rates. In their chapter, the authors shed light on OER repositories, learning analytics, and learning analytics dashboards and present an implementation of a research-driven learning analytics dashboard for displaying OER and their repositories that allows the visualisation of educational data in an understandable way for both educators and learners. Moreover, they present a case study of a learning analytics dashboard for displaying OER that shows information on the existing German OER repositories as part of the EduArc project.

3 Conclusion

We hope that this book will provide readers with as comprehensive and interdisciplinary a perspective as possible on the question of how to design learning ecosystems on the internet as a teaching/learning space in general. Our response to this is to introduce DLE to enable education as a public good.

We also hope that readers will be motivated by the various sections and chapters to make their own efforts, be they theoretical, conceptual, or practical.

If this book serves as an impulse or guideline to trigger these efforts, one of our major goals will have been achieved.

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Concepts

Distributed Learning Ecosystems in Education: A Guide to the Debate

Daniel Otto and Michael Kerres

Abstract

Learning spaces are vital for education but subject to rapid transformation. The internet is the emerging space where learning takes place. The concept of learning ecosystems reflects the idea that in today's learning processes, different elements interact and influence each other. For higher education, a learning ecosystem comprises all services, resources, and environments within the institution that enable or support learning processes. However, this chapter argues that, although learning ecosystems are increasingly established in higher education, essential features that are missing are their permeability and interconnectedness. The chapter aims to close this gap by introducing the concept of distributed learning ecosystems (DLEs). DLEs follow the idea of establishing a link between decentralised learning ecosystems (consisting of content repositories and educational resources). Thus, DLEs serve as an integrated approach that enables learners to access and use learning content and share resources. With reference to the other chapters in the book, the paper illustrates challenges and solutions on the road to DLEs.

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1 Introduction

"May you live in interesting times."

This saying refers to a famous Chinese curse whose origin is not clearly documented. Against the backdrop of the challenges education is currently facing, we indeed live in interesting times. The digitisation of society and, thus, education, discernible in the emergence of new technologies, has dismantled our traditional view of teaching and learning. No longer can both be solely regarded as educational practices where individuals gather in a physical classroom and interact socially face-to-face, using different written learning materials. While the Covid-19 pandemic and the sudden dependence on technological solutions to maintain communication have created various pragmatic answers to mastering the challenge of "emergency remote teaching" (Charlges et al., 2020), they have disguised a more fundamental underlying question.

What appears evident is that we need to rethink how we organise teaching and learning processes. We need to admit, more than ever, that the dichotomy of an "analogue" and a "digital" world has become blurred. Education can no longer be perceived as having a rigid border between classroom and online experiences, computer-based and computer-less activities, or virtual and physical campuses (Dillenbourg, 2008). Although many misperceptions exist and might persist about "digital learning" (Kirschner & De Bruyckere, 2017), studies have demonstrated that several benefits can arise from implementing digital technologies embedded in a proper instructional design (Kerres & Otto, 2022). These benefits include temporal and spatial flexibility, facilitation of the organisation and management of study tasks, more visual forms of learning, and the provision and retrieval of teaching and learning materials (Henderson et al., 2017; Kerres & Otto, 2022). Especially the latter tells us that there is a need to reflect on a contemporary design concept for an educational learning architecture that supports achieving this and other benefits.

However, what is often less obvious in the debate about teaching and learning in the digital age is a subtle, yet far more fundamental question. The internet has perpetuated itself as the central space for teaching and learning, and its growing importance has forced educational stakeholders to reconsider patterns of conceptualising educational offers and traditional models. This sudden appearance of new (business) models is, for instance, visible in the way we understand and publish (open) research and teaching material. While, for a long time, the only way of releasing new research and teaching material was through publishers, this has been challenged by several new online journals and open textbook initiatives (see the chapter by Kimmons and Irvine).

While this case only illustrates one example of new business models, nobody can deny our reliance on the internet. However, where, in the 1990s, the question raised was, “will the Internet transform higher education?” (Baer, 1998), we meanwhile know that answer and have to ask a more fundamental question: how do we want to design the internet as the central space for education?

Based on our assessment, three main narratives can be observed in the current debate regarding this question.

1. The first narrative is the internet as a liberal market. This market is only lightly regulated, and actors are liberated to self-organise and run their business models with minimal restrictions and to provide education at prices that can be freely determined. Private and state actors compete here; state actors can operate in the market. The US could be regarded as one example of this narrative, whose vulnerability was visible in the debate about the prospects of Massive Open Online Courses (MOOCs) for open education followed by the accusation of open-washing (Weller, 2013) and misusing them as a business opportunity (Otto et al., 2018).
2. The second narrative is the internet as a state-regulated space. While in the beginning, the internet was perceived as offering unconstrained freedom without control, countries like China and Russia have demonstrated that, even in the digital age, the opposite end of the regulatory spectrum, which can be labelled “cyberpaternalism”, is possible (Krönke et al., 2018). Education here is a quasi-monopoly under the control of the state, and certain tendencies can be encouraged or prevented, as, for instance, China breaking up its booming private tutoring sector.[1]
3. The third narrative would be the internet enabling education as a public good. This narrative is founded on the conviction that education fulfils much more than an economic function. Consequently, education must rely on free access and open educational material offered at no (or marginal) costs. The internet is configurated to empower education as a public good, and its consumption is characterised by being non-rivalrous and non-excludable. A state intervention is only legitimate when critical defects of the provision of the public good occur that need to be corrected.

[1] https://www.ft.com/content/1a7476ee-bcd4-45ac-a165-3418e2de286a.

While we find no prime example of this third narrative yet, we regard the European Union with its multilevel governance approach as a discursive forum where such a debate should occur. The European Union has the opportunity to establish and implement respective policies to realise the vision of education as a public good on the internet. We are presently in the middle of this negotiation process that is manifest in the various concepts of Open Educational Resources (OER) and Open Education.

With our chapter, we aim to contribute to this discourse by introducing the idea of distributed learning ecosystems (DLEs). This can be regarded as one answer to how, from an educational technology perspective, the internet needs to be configured as a space to support education as a public good. We hope our input contributes to the broader debate.

2 Contemporary Learning Architectures as Ecosystems

To best describe our idea of contemporary educational learning architectures, we use a learning "ecosystem" metaphor. Metaphors are widely resorted to not only in education to elucidate complex objects or relationships by replacing them with something more vital, more descriptive, or semantically richer. A learning "ecology" is a competing metaphor for "ecosystem" that has become popular in educational research. Based on their systematic review, Sangrá et al. (2019) explain learning ecologies as a broad semantic space for characterising innovative ways of learning and for conceptualising the relationships between the formal and the informal as a continuum across several learning contexts, mediated by digital technologies. However, they state that only a few educational applications exist currently that follow such a broader view, particularly regarding recent technology-enhanced learning approaches. Therefore, the term's broadness might hinder a further conceptual development.

By introducing the term *learning ecosystems*, we primarily aim to reach beyond the spatial dimension of a traditional view on the organisation of learning, which is strongly associated with buildings, rooms, and walls in physical spaces. The ecosystem metaphor emphasises that we are dealing with an interrelated ensemble of different influencing entities that are in dynamic interplay with each other. In contrast to a spatial view, learning in digital and analogue environments is considered to be dynamically developing and interconnected; there is growth and unexpected changes, parts die off, strengthen themselves, and develop further in an evolutionary way. Therefore, these developments should not be conceptualised as linear, but must rather be understood as emergent processes. Agents' actions not only have mutual effects but can also give rise to new formations. Knowledge no longer emerges (only) in the mediation via algorithms, programmes, or designed spaces and in the exchange between teaching and learning instances. More actors are coming into focus: The producers of knowledge resources, the editorial offices and agencies that select, evaluate, and provide them, and other intermediary actors that ultimately have a decisive influence on our knowledge environments. In this context, digital technology itself is ascribed the status of an actor. Consequently, digital technology can also be understood as an actor alongside human actors (teachers, learners) (actor-network theory (Fenwick & Edwards, 2010)). The ecosystem metaphor incorporates and broadens this perspective by focusing on actors' diversity and interactions.

The description of digital (networked) learning technology as part of an ecosystem uses a metaphor originally related to living entities. Learning is no longer (only) considered in spaces that are available to teachers and learners, but as constant renewal of knowledge, which is (re)constructed in the network and regenerated through activities of (re)use. Computers and digital media are technical objects, and in this respect, the question arises to what extent the term ecosystem can be used meaningfully in this context or perhaps contains misleading implications. The hardware consisting of computers and networks and the associated operating software can be described as a "habitat" in which people create, provide, and use digital tools, applications, and content. The term ecosystem in this context means that there are delimited areas in the living environment in which different digital hardware and software elements interact on different levels, which are structured in themselves to function, and which develop in a relatively small exchange with other ecosystems. The users themselves, who contribute significantly to the ecosystem remaining "alive" by providing new contributions and content, also play an essential role.

An economic view of the internet initially shaped the view of digital technology as an ecosystem: The computer industry recognised that it could be attractive not only to sell a device or a software programme but also to engage people through a wide-ranging and tiered offer. Bea and Haas (2016) explain the importance of such an ecosystem for strategic management: thinking in ecosystems opens up a new view of customers and competition. A digital ecosystem comprises several companies that jointly produce values for customers, who are themselves to be understood as part of the system. Messerschmitt und Szyperski (2005) describe that software is neither evidently an intangible nor a tangible product and is, thus, subject to different laws of production and dissemination than traditional goods. Software is mainly created in the ecosystem of a technology provider. Suppliers and producers are active in this environment, which is based on the products and services of these providers. This means that the interaction of the actors plays a key role: it is about building a connected group of entrepreneurs and users, a community that creates shared value over time. The concept of digital ecosystems, thus, emphasises more clearly—in contrast to the market concept—the distinctive interconnectedness of the network of actors as it is well known in the IT world.

3 Establishing Distributed Learning Ecosystems Based on Open Repositories and Learning Resources

The remarks made above about learning ecosystems are valid also for the discussion about openness in education. The latter refers to a situation where teachers and learners are not the pure recipients of content produced by others, for instance, publishers or companies, but are empowered to be creators or distributors of learning content. Moreover, it allows teachers and learners to collaborate with others and receive feedback on their materials or help others improve theirs.

Bozkurt and Stracke (see chapter) reconstruct the concept of openness and its relation to the core values of open education. Although openness is a term often bound to its philosophical roots, the authors explore openness in education and argue that it reaches its full potential when practised from the perspective of ecosystems. In this context, openness perceives learning as an ongoing action in coordination with human development, placing people at the centre of the whole learning process, and the ecosystem view offers a roadmap to ensuring the sustainability of learning. From this point of view, the nature of learning and ecosystems is complex and chaotic, yet underlying patterns govern complexity and chaos. Bozkurt and Stracke conclude that openness provides accessibility, transparency, and democratisation, thus stabilising ecosystems. Thus, openness empowers ecosystems, and, in turn, ecosystems amplify openness.

This understanding of the potential of the nexus between openness and ecosystems for interaction and collaboration between actors and networks alike makes it essential to consider the enabling conditions for openness in learning ecosystems more closely. In our view, it is compelling that the entire spectrum of learning ecosystems can only be achieved in a distributed and also open learning infrastructure that is primarily based on open learning resources. Only in that way, the promise of interactive, collaborative, and interconnected ecosystems unfolds its full potential. Therefore, the openness of the different learning ecosystems is vital for enabling actors to find, create, share, and reuse (all available) learning resources.

Why should we think of learning ecosystems as distributed? Looking at repositories in higher education worldwide, we can state that the educational landscape is highly fragmented (Otto et al., 2021; Santos-Hermosa et al., 2017; UNESCO IITE, 2019). One reason is that most countries' higher education systems guarantee their universities a high degree of independence and autonomy concerning self-management. As a result, numerous higher education institutions have already established (OER) infrastructures to store resources and metadata. However, in many cases, data protection and data access rights have high priority in institutions and prevent free access to materials and metadata.

Given the decentralised nature of the structure of the educational systems in most countries, the establishment and operation of central infrastructures in the form of core repositories or referatories for OER is neither a realistic nor a desirable option, neither for higher education nor across educational sectors. Moreover, since there are already recognised architectures of OER services in many educational areas, independence, subsidiarity, and user loyalty are rated higher by the providers of these than possible advantages of a more centralised structure. As a result, the already grown network is unsuitable for developing visions of single national or European repositories and referatories.

Against this backdrop, the networking and interconnectedness of existing (sub-) infrastructures/ecosystems in a distributed learning ecosystem have to be advocated. A distributed learning ecosystem enables solutions such as aggregation mechanisms for digital learning resources and repositories (e.g., metasearch engines), which address the disparately distributed and partially separated resources and communities and links them based on interoperable verification and exchange routines without restricting the diversity of field-specific offers. Initiatives to bring together international networks, national structures, and local needs are already emerging. Santos-Hermosa (see chapter) investigates some of the currently ongoing initiatives to set up national and European repositories. The initiatives aim to create global, international, or national ecosystems (such as 5Xgon, Open Discovery Space or ENCORE+), while others provide a connected national infrastructure (OERSi and Open Education Austria). They all have in common that they seek ways to influence the future of OER by applying the latest technologies to the educational ecosystems.

Hence, the design of ecosystems must be open and multifunctional and allow room for experimentation so that different approaches can develop for different requirements. Competing approaches should also be supported and tested so that, in the long term, providers and services can emerge that meet the needs of users in a particular way. Distributed learning ecosystems should, thus, encompass a variety of methods and approaches. Therefore, it is necessary to mediate between different existing platforms, projects, and institutions in the diverse ecosystems. Users can only select particularly suitable services and platforms if they are given an overview of the existing offers. Only if services can be used and tested side by side, users will be able to choose based on their own experience. To this end, it seems appropriate to define technical standards for exchanging information in the medium term, which will be regularly reviewed and adapted. In addition, the coordination of measures to create, connect, and integrate different approaches into the distributed learning ecosystems should be subject to the principles of openness and transparency.

The next crucial element for a distributed learning ecosystem is incorporating OER as one of the key components of openness and open learning (Otto & Kerres, 2021). Meanwhile, the concept of OER can look back on a history of almost 20 years and has substantially evolved since the term was initially coined by UNESCO's, 2002 Forum on the Impact of Open Courseware for Higher Education in Developing Countries (UNESCO, 2002). Although no canonical definitions exist, the latest definition provided by UNESCO defines OER as being

> "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 permit no-cost access, reuse, re-purpose, adaptation and redistribution by others." (UNESCO, 2019, p. 3 f.)

The core idea embedded in OER are to facilitate access to educational materials and empower people to the 5Rs; to retain, reuse, revise, remix, and redistribute it (Wiley et al., 2014). Thus, OER is are meant to broaden access to education, reduce material costs, and improve teaching and learning quality. However, regarding their pedagogical value, it needs to be stressed that OER are primarily content and not an educational model or practice per se (Otto, 2019). Therefore, pedagogical concepts have evolved from the debate about the practical implications of OER such as Open Pedagogy and Open Educational Practices (OEP) (see other chapters in this book). While no rigid definitions for both concepts exist, OEP describe open practices that can but do not have to entail the use and creation of OER (Cronin & MacLaren, 2018).

On the other hand, the concept of OER-enabled Pedagogy, defined by Wiley and Hilton as one strand of Open Pedagogy, covers educational practices that are only possible due to the 5R activities (Wiley & Hilton, 2018). It is essential to consider OEP in the light of the repositories, or rather, learning ecosystems. Hiebl et al. (see chapter) clarify that repositories, and infrastructures in general, play a crucial part in constraining or enabling open learning and teaching practices. Their chapter shows how current functionalities of higher education repositories provide the potential for supporting OEP, which they frame within the practice theory. The authors further demonstrate how current functions shape OEP in repositories for learning and teaching resources.

Despite the necessity of OER and adequate infrastructures for the desired OEP in learning ecosystems, it must be stated that the overall adoption of OER is still low in all academic areas worldwide (Otto et al., 2021). As a result, over the past decades, OER research has primarily concentrated on awareness (or the lack thereof) and barriers to OER, which has led to various single case studies (with partly inconsistent results). Systematic reviews (Bozkurt et al., 2019) and meta-analyses (Otto, 2019) that aggregated these findings found that a lack of time, legal uncertainty, and institutional obstacles were the most predominant barriers to OER adoption. An additional difficulty is that teachers are habitually consumers rather than producers of OER and mainly cherish the opportunity to be able to adapt OER according to their individual needs and use them without facing legal problems (Otto, 2019). On the other hand, little is known about the reuse and remix, and scarce activity is observable regarding the redistribution of material. Thus, while some argue that there is presumably a "dark use" of material in education, there is, hitherto, no hard evidence corroborating this assumption (Beaven, 2018).

In their chapter, Schuwer and Baas present two process models that visualise educators' and students' activities to create educational resources. They connect them with the OER competency framework to support the reuse of OER. Mapping this framework reveals that educators as well as students need professionalisation to acquire the necessary competencies. Competencies in finding, evaluating, and reusing resources are crucial, and institutions should extend their support activities.

The findings mentioned above demonstrate that one significant challenge for the use and reuse of OER, which is also associated with the lack of time, is finding a sufficient number of relevant resources within a reasonable time that are relevant, up-to-date, and of high quality (Heck et al., 2020). Habitually, the first source of information for learners and teachers when looking for resources is their university's (OER) repository. After reviewing the state of repositories in higher education, Santos-Hermosa (see chapter) demonstrates that there is an increasing number of universities offering institutional repositories for OER produced by their faculty, students, and staff. These institutional repositories allow storing and accessing material produced within the university. In this way, they increase the visibility of those engaged in OER and their activities and create awareness for OER. Repositories also facilitate compliance with Open Access mandates and policies. Santos-Hermosa notes that to increase the suitability of institutional repositories, these need to include ease of access, sharing and collaboration, and profile enhancement (see chapter for further details).

To sum up, repositories appear to be a vital component of learning ecosystems and support teachers and learners in engaging in OER. An often-discussed aspect regarding the increase of repositories is institutional measures such as offering support (e.g., technical, legal) and specific training or developing and implementing policies or institutional strategies. These measures can strengthen a person's volition, one of the main factors influencing teachers' intentions to adopt OER (Baas et al., 2019). However, it still does not solve the problem of finding adequate resources in time. The literature emphasises that perceived ease of use and perceived usefulness are the main predictors of teachers intentions to use OER (Hew et al., 2019). Yet, these findings partially contradict those that highlight volition as the main significant predictor.

However, to address the challenge of the ease of use and the perceived usefulness of OER and the related infrastructure, it appears worth concentrating on the overall design of distributed learning ecosystems. Accordingly, if we imagine a teacher looking for OER to equip or enrich their teaching scenarios, habitually the search will start within the institution OER repository, where OER the university staff has produced is available. When the search results in the repository are unsatisfactory, the teacher can search in other OER repositories available worldwide. As time is one of the determining factors, the teacher will only spend a limited amount of it searching each repository individually. Therefore, after a short period that differs individually, most educators decide to use a basic Google search to find appropriate OER (Cortinovis et al., 2019).

On the other hand, more and more meta-search engines such as the Mason OER Metafinder (MOM) and the OERhörnchen have become available to assist teachers in searching for OER. A problem that remains is that these meta-search engines have only limited access to the various OER repositories already existing. This shows that although more and more OER emerge, they are not available in distributed learning ecosystems "as such". Their provision relies on open technological infrastructures and related open services that should be designed as an open informational ecosystem. Hitherto, even in the case of OER repositories, we mostly find closed informational ecosystems that preserve educational resources within specific boundaries.

4 Opening and Closing Learning Ecosystems

As mentioned, OER is not available "as such". Its full availability beyond the respective repository and, hence, in distributed learning ecosystems relies on stakeholders' consensus to jointly provide (meta-) information, particularly outside the distinct boundaries. However, if this does not happen, even OER repositories that are genuinely perceived as open must be considered closed ecosystems that keep educational resources within their boundaries and, therefore, miss their contribution to distributed learning ecosystems and, consequently, open learning.

Whereas obvious closure mechanisms in ecosystems can exist, such as applying a paywall that restricts access via pay per view or pay per subscription, a requirement for registration on a website can also be perceived as a mechanism of "closure" as it restricts immediate access to a resource. In the latter case, users disclose and thereby "pay" with personal information, such as an email or home address. However, it can be argued that some instructional approaches demand registration, for example, when a service provides interactive features, such as enabling the 5Rs for the OER. Concerning distributed learning ecosystems, hiding information behind barriers or hindering their exchange must be seen as critical regarding distributing the material. Search engines will be unable to locate the resources behind such (payment or registration) hurdles.

The previous explanations of OER and ecosystems have shown that educational resources are not automatically open to learners. Even "open" material faces challenges in terms of, e.g., use and availability, so it would be naïve to think that when teachers put resources "on the web" for others, there are no intermediary entities—private or public institutions—that are ultimately responsible for making these resources retrievable on the net. Although the production chain behind resources and the processes for making them available are less visible and the processing is seamless, it is still the network behind the network that decides; for example, if and how others can find resources, how these interconnect with other resources and services, how they eventually reach a course, and how changes or enhancements to an (open) resource can be traced back. For that reason, the discussion about OER specifically and open education in general occasionally ignores the relevance of the openness of repositories and related intermediary services like, for instance, meta-search engines and how they operate.

Consequently, many ecosystems cannot initially be regarded as open. On the contrary, they might entail tendencies to opening as well as closing their boundaries. However, flourishing ecosystems must be open enough to encourage teachers and learners to develop new resources and services in them. Likewise, they must be close enough to enable teachers and learners to remain in control, to track their resources and control how they can be further used. Recent studies with OER-experienced lecturers about the design of OER repositories confirm that they want to be informed about changes or improvements to their resources made by others and want to receive feedback on their published material (Otto, 2021). The results further demonstrate that users need assistance and support systems, for instance, when they upload resources in a repository or assign metadata to resources. One of the most important problems with the latter is the scarcity of quality metadata that adequately and comprehensively describe resources, and there are many incompatible standards to specify these metadata (Cortinovis et al., 2019). An additional key challenge is a well-known reluctance of most authors of resources to even provide metadata at all. Several studies have suggested metadata sets that describe OER more systematically and, thus, enrich and facilitate the metadata report to improve OER availability and OER description (Herrera-Cubides et al., 2022).

Menzel (see chapter) demonstrates how commonly agreed metadata standards contribute to distributed learning ecosystems. In his case study, he describes how operators of different OER repositories from several federate states in Germany (HOOU, Twillo, ORCA.nrw, VCRP, VHB, ZOERR) collaboratively developed a metadata profile in the area of higher education. Against the backdrop of the FAIR principles (Findable, Accessible, Interoperable, and Reusable), it is shown how meaningful metadata description can be achieved by balancing the prima facie antagonistic demands of describing resources as detailed and accurate as possible while only providing essential information to keep the threshold for authors as low as possible. In conclusion, Menzel emphasises that metadata standards are crucial to connecting repositories, thus permitting federated search, and harvesting metadata, e.g., by search engines or other interested parties.

The metadata standard problem exemplifies the general importance of the discoverability of OER, and there are many ongoing attempts to address this (Cortinovis et al., 2019; Otto et al., 2021). Predominantly, these attempts encompass establishing new OER repositories with search services or federated repositories that bundle resources from different institutions. However, the question is whether developing an additional OER search portal or engine improves or rather fragments the current landscape and the discoverability of OER further. Odds could be that teachers and learners go astray on their way to finding OER because of the difficulties of searching and locating OER, which, ultimately, retain teacher and learners within, e.g., Google or YouTube. Recent literature reviews reaffirm that searching and locating OER is still a significant problem (Abri & Dabbagh, 2018).

As already described, poor metadata allocation is one key aspect that makes it difficult to locate resources. However, the more pressing challenge regarding the overall structure and, thus, the aim to establish distributed learning ecosystems is that the different repositories must be interconnected. Networks of connected servers or services on the internet conjointly or cooperatively establish an environment for finding and providing resources to a larger public. This includes functions for delivering content and related, complex, value chain functions, like generating, editing, assembling, annotating, tagging, commenting, or linking information resources. In such ecosystems, several providers coexist; hence, their collaboration relies on common standards for interface content and metadata.

When creating and editing content, modifications and adjustments can result in new resource versions. Schroeder (see chapter) discusses these concerns of managing versions in distributed learning ecosystems by addressing the main obstacles such as metadata and persistent identifiers, tracking changes, further developments, and availability of new versions.

Open ecosystems allow any content provider to "plug into" the ecosystems by providing metadata that can be retrieved from a reference platform (referatory). On the other hand, closed ecosystems can entail a one-stop solution that combines all the described functions. They can, however, also be a network of confederated servers that jointly keep the system's boundaries closed.

Ebner et al. (see chapter) present a compelling example of how a repository can contribute to an open ecosystem. The case study about their experiences at Graz University of Technology illustrates how a plug-in and appropriate interfaces were integrated into the learning management system (LMS). This integration into the LMS enables course components publication in the university's OER repository.

Moreover, the authors demonstrate how adding the appropriate metadata renders resources findable in the Austrian OER referatory. Finally, besides the technical concepts and their implementation, the authors clarify the essential strategic considerations for steering this process, such as appropriate training and mechanisms for quality assurance.

Abdel-Qader et al. (see chapter) provide another example from a rather technical point of view. They disclose specifications and requirements for connecting different OER repositories using the Learning Object Metadata (LOM) standard. The authors disclose how this process works at the backend and explain the entire process of connecting repositories. They start with harvesting the metadata and end with how to store the processed data into files to be used in the frontend. The chapter comprehensively describes how to connect OER repositories using the LOM standard, while trying to be as straightforward as possible to enable non-technical staff to replicate such a process or at least stages from it.

5 Conclusion: Towards Distributed Learning Ecosystems in Education

This chapter contributed to the emerging discussion about designing contemporary open infrastructures for teaching and learning in the digital age. Therefore, we introduce the idea of learning in distributed learning ecosystems. We use the metaphor of an ecosystem as it acknowledges that teaching and learning, the communication of knowledge, and collaboration on the internet are not merely about learning spaces but about how the different learning spaces are interconnected. The spatial dimension predominantly focuses on the features and design of the space and ignores what lies between the spaces, the interconnectedness and relationality of spaces. When we speak of ecosystems, the characteristics of entire areas of the internet come to the fore. The question we bring up is how these areas should be structured to enable open teaching and learning.

First, it is essential to accept that ecosystems can include closing and opening mechanisms that must be considered crucial elements for designing distributed learning ecosystems. Only if ecosystems remain open beyond specific, often invisible boundaries, they can unfold their potential.

As described, these boundaries are normally obvious, as in the form of paywalls or a mandatory registration with an email and sometimes even a postal address. However, equally importantly, boundaries can be hidden or invisible; for instance, if ecosystems are not providing compatible technical standards or mechanisms to exchange metadata.

We then present the implications of this rather conceptual discussion using the debate on OER and the related repositories and referatories. In general, the concepts of OER and openness constitute critical components to facilitating distributed learning ecosystems. However, we first outline that OER are facing several challenges regarding their adoption in education. While these challenges are often related to individual or institutional factors that hamper or facilitate the use of OER, we aim to point out the importance of the overall learning architecture perspective. If the various existing ecosystems are operating as open learning ecosystems, meaning that they allow the exchange with other ecosystems, they can contribute to what we describe as a distributed learning ecosystem (see Fig. 1).

To illustrate the practical implications and the contribution of open learning ecosystems to a distributed learning ecosystem, we refer to the other chapters in this book. The authors of the chapters show innovative and pragmatic solutions to how technological developments and repositories can add to a distributed learning ecosystem; for example, via integrating plug-ins into LMS or connecting OER repositories using the LOM standard. Still, these examples are only a fraction of

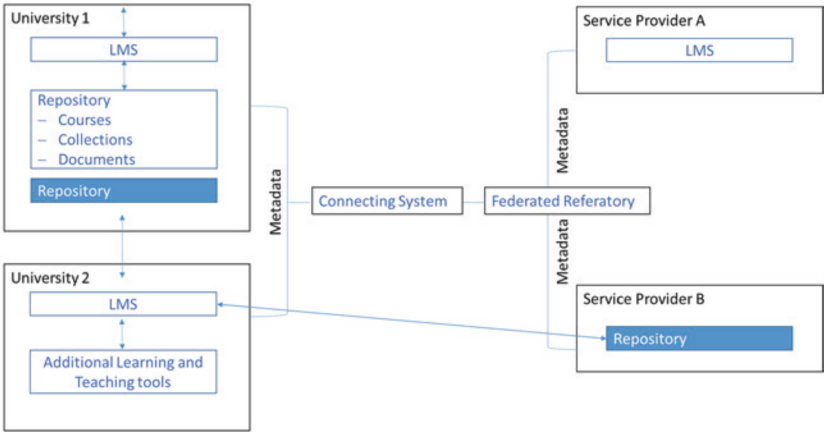

Fig. 1 Distributed learning ecosystem 1

the possibilities that may arise from open thinking about the design of open ecosystems.

We invite researchers and practitioners to provide further input and thus expand the range of distributed learning ecosystems in education!

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The Shift Toward Openness in Education and the Implications for Learning Ecosystems and Ecologies

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Abstract

Openness in education, a concept that includes many universal values and philosophical roots, assumes the objective that learners should be at the centre of the learning process. In recent years, the concept has emerged as a major topic of interest due to the expansion of its scope and the opportunities it offers. In this book chapter, the impact that the digital transformation in terms of online networked technologies has had on openness in education is explained and the characteristics of ecosystems and learning ecologies are presented through a socio-environmental perspective. In exploring openness in education, the case is made that openness in education can reach its full potential when it is practiced from the perspective of the ecosystem, educational adaptation, and the learning ecology.

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1 Introduction

If it doesn't open… It's not your door…—Anonymous

We need to understand openness in education if we want to benefit from the perks it offers in the digital knowledge age, where online networks have emerged as ecologies for many fields, including teaching and learning. Therefore, we must ask the question: What does openness in education mean and how can we define it? This is a critical question that has been asked for centuries. However, there has never been a single answer or formula that could adequately define or explain it, as openness is a liquid term that has been shaped by different local and global needs throughout time. In fact, openness in education is more than a term able to be bounded by a definition; rather, it is an educational philosophy. While its core ideas and principles are universal in their nature, its practice has always emerged in different forms due to the changing nature of educational ecologies. This book chapter positions and discusses openness in education within a broader framework, where teaching and learning are viewed as practices occurring within specific educational ecologies. In this sense, openness in education is explored from the perspectives of an ecosystem and a learning ecology, aiming to explain how these terms relate to each other. Thus, we first explain the concept of openness in education before turning our attention to the idea of ecologies and ecosystems, where we focus on how online networks empower learning ecologies and promote openness.

2 Openness in Education

According to Baker (2017), openness in education refers to "the attitude and culture of freedom, justice, respect, and openness, the absence of barriers, the promotion of sharing, accessibility, transparency, collaboration, agency, self-direction, personalization, and ubiquitous ownership" (p. 131–132). In line with this understanding of openness, Zawacki-Richter et al. (2020) report that the term is associated with critical pedagogy and add that openness is "a colour with many shades, a notion with pluralistic and inclusive connotations, and a stance that defends widening participation" (p. 321). Accordingly, it can be argued that openness in education strives to shape education into its ideal form by advocating a range of values and principles that would lead to equity and social justice in education by positioning human-centred approaches at the core of its practices. Although this effort is already rooted in earlier practices of openness in education, its scope has been strengthened and its target audience has expanded with the advent of online networking technologies.

The openness in education paradigm "emerges from a complex historical background, and its futures are intimately tied not only to open source, open access, and open publishing movements but also to the concept of the open society itself and its [attendant] meanings" (Peters, 2008, p. 10). It is important to understand that the term is inherently broad in its scope, and that the "open aspect of open education refers not only to the dimensions of legal openness (e.g., accessibility and availability) but also to the dimensions of operational openness (e.g., open design frameworks) and of visionary openness (e.g., open policies)" (Stracke, 2019, p. 185). However, the developments in online networked technologies, such as the tools available for searching and accessing information across vast networks (Deimann & Farrow, 2013), the rich interactive communication, and the ability to be socially present, have changed the educational landscape and provided more opportunities, thereby broadening the use of the term 'open' as a descriptor (Smith & Seward, 2017) and creating an explosion of interpretations of the term (Pomerantz & Peek, 2016). To better conceptualize openness, Smith and Seward (2017) proposed to understand the concept of openness as a social praxis and suggested three main processes, namely, open production, open distribution, and open consumption.

- Open production refers to participation being free and voluntary so that anyone can contribute to the production process.
- Open distribution refers to the free provision of generated content, with no prerequisites or barriers.
- Open consumption refers to the 5Rs (retaining, reusing, revising, remixing, and redistributing) (Wiley, 2014), with the additional practice of 'creation' to produce Open Education Resources (OER) from scratch.

While practices related to openness in education have gained a lot of attention from the 2000s onwards, their wider acceptance and the related use of OER and repositories in educational processes are progressing slowly (Otto, 2019). One possible reason behind the slow progress is the confusion between OER as materials and open education as a broad concept for innovative learning designs and processes (Stracke et al., 2019). Other obstacles contributing to the slow progress include issues related to developing a legal understanding and institutional policies, creating sustainable OER projects, ensuring quality assurance, building greater awareness and readiness for adoption, discoverability, and integration, and lastly, copyright and intellectual property issues (Atkins et al., 2007; Henderson

& Ostashewski, 2018; Luo et al., 2020). Arguably, one of the main reasons hindering the wider acceptance is the missing link between OER and educational ecosystems (Kerres & Heinen, 2015). The study by Atenas et al. (2019) supports this view, reporting that the development of national and institutional policies that focus on opening up education seems to be lagging behind. Furthermore, while there are policy documents addressing the issue of bringing greater openness to education (Marin et al., 2020), such initiatives are not really reflected in educational ecosystems. Recognizing this problem, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has discussed and approved the first UNESCO Recommendation on OER (UNESCO, 2019), with the hope that this will lead to major changes as the recommendation requires the annual reporting by all 193 UNESCO member states on the status and improvement of OER strategies and implementations (Stracke, 2020).

Open education, as the reflection of openness in the educational landscape, is "a values-based and mission-driven movement" (Biswas-Diener & Jhangiani, 2017, p. 5) and involves the combination and interplay of different dimensions to facilitate open learning processes and generate the transformation of education towards learning ecosystems (Stracke, 2017). In highlighting that the culture of openness and the ecologies of open pedagogy are no ends in themselves, but rather ongoing processes, it has been argued that higher education institutions should empower ecologies and the culture of open pedagogies to facilitate learning as a lifelong activity, taking advantage of digital technologies and digital transformation (Ossiannilsson, 2018). As a transversal enabler of opening up education (Inamorato dos Santos et al., 2016), the digital transformation of education has influenced on-campus and off-campus teaching and learning within the framework of open, online, and distance education (Qayyum & Zawacki-Richter, 2019). Digital transformation has been a catalyst for practices related to initiatives aimed at opening education. Likewise, it has been argued that digitalization can "give a high level of organizational flexibility and a high degree of procedural openness" (Orr et al., 2019). The digitization and digital transformation of education are mostly related to "enhancing and even transforming the learning experience, insofar as they enable open, flexible, disaggregated, and distributed learning, as well as connection and communication" (Xiao, 2019, p. 516). Stressing the importance of digitalization, The Digital Education Action Plan (European Commission, 2020) proposes two priorities, namely, fostering the development of a high-performing digital education ecosystem and enhancing digital skills and competencies for the digital transformation.

The developments in the digitally intense twenty-first century did not only change the nature of knowledge (Bates, 2019), but also the nature of values, environments, demand, and information and communication technologies (ICT) in the field of open, online, and distance education (Qayyum & Zawacki-Richter, 2019). In a broader sense, with the inception of online networked ecosystems (Jackson, 2013), these developments resulted in the emergence of networked individuals (Rainie & Wellman, 2012), networked societies (Castells, 2004), and networked learning (Networked Learning Editorial Collective et al., 2021). All these developments have affected education in many ways, for example, by creating greater accessibility, flexibility, and affordability, features highly associated with the openness philosophy and open learning. However, to better understand the implications of these developments, we need to examine these concepts as change agents that have sent ripplesnot only in a specific field, but throughout the entire educational ecosystem.

Online networking technologies (Brown & Adler, 2008) and globalization (Stracke & Shamarina-Heidenreich, 2015) have deeply affected openness in education, resulting in a capacity increase in its practice and diversity in its realizations. Open online distance learning has emerged in different forms, such as open access, open data, open policies, open licence, open scholarship, and open science, all of which have been fuelled by open educational practices (OEP), massive open online courses (MOOCs), and OER (Knox, 2013; Koseoglu & Bozkurt, 2018; Mulder, 2015). Many higher education institutions have, as a result, implemented open education systems based on models like OEP, MOOCs, and OER. However, it is questionable if these models are implemented as part of the learning ecosystem or as an isolated practice. Although some higher education institutions are motivated to open their practices, it is (more) important how they define, position, and contextualize these practices in their local or global ecosystems on all educational levels, especially on the strategic macro level. We, therefore, need to look at these applications not from a granular perspective but from a broader perspective, such as educational ecosystems and learning ecologies.

3 Ecosystems and Learning Ecologies

Eco etymologically originates from *oeco* in Latin, which refers to a household, and *oikos* in old Greek, which refers to a house. To expand our perception of learning rather than confine it to specific onsite practices, we need to support and empower our ecosystems so that learning can be a sustainable, ongoing practice for global development. The idea of ecosystems in education involves seeing our surrounding environment as a home for learning and, thus, the term has strong ties to the philosophy and idea of openness in education.

The terms ecology and ecosystems are used to explain interactions between biotic and abiotic entities and their environments (Jackson, 2013). An ecosystem is “basically an open, complex, adaptive system comprising elements that are dynamic and interdependent” (Brown, 2000, p. 19). An ecosystem view encapsulates the systems and all of its components (Frielick, 2004). Simply put, biotic and abiotic entities and the interactions among them constitute the essence of ecosystems (Pickett & Cadenasso, 2002; van de Heyde, & Siebrits, 2019).

The ecosystem perspective is reflected in the systems view in open online and distance education. Accordingly, there is a set of different systems, where a system can be one subsystem within a larger system. Moore and Kearsley (2012) explain the systems view as follows:

> Because distance education requires using a range of technical and human resources, it is always best delivered in a system, and understanding a distance education program is always best when a systems approach is used. A distance education system consists of all the component processes that operate when teaching and learning at a distance occurs. It includes learning, teaching, communication, design, and management (Moore & Kearsley, p. 9).

Human development is one of the central ideas in ecosystem theories. For instance, the ecological systems theory of development (Bronfenbrenner, 1979) argues that human development is linked to ecosystems and bases this on a model of five environmental systems that all influence each other. Applied also to technology-driven online learning environments (Johnson & Cooke, 2016), Bronfenbrenner’s theory (1979) focuses on human interaction and actions with numerous environmental factors (Bronfenbrenner, 2005). Accordingly, a microsystem is an immediate environment that refers to groups or institutions like families and schools; a mesosystem encompasses the interactions between microsystems; an exosystem includes formal and informal social settings; a macrosystem pertains to cultural context; and lastly, a chronosystem consists of all environmental changes, such as socioeconomic shifts or historical turning points. Bronfenbrenner (2005) also introduces the concept of ‘bioecology’ in reference to humans’ own biology as a dimension of microecology. From the perspective of learning, bioecology provides a more comprehensive understanding by adding cognitive processes and personal learning differences to socio-environmental factors as variables that affect learning. The significance of Bronfenbrenner’s (1979) model lies in its emphasis on socio-environmental developments and the explicit and implicit effects these have on individuals, and thus, learners, from the perspective of education. Moreover, considering that learning is a complex process involving many direct and indirect factors, ecological systems theory provides a comprehensive base by situating humans at the centre of the multi-layered learning ecosystem.

A learning ecology is considered formal when the ecology is determined by the educational institutions or instructors based on learning objectives, and informal when the ecology is determined by groups or individuals based on their own learning needs (Jackson, 2013). From the perspective of formal education, most educational institutions isolate themselves from their ecologies and focus on learning as a cognitive process rather than a social process (Frielick, 2004), which results in learning experiences that are unmeaningful and disconnected from the context of real life. Besides being isolated from the educational ecosystem, it is not uncommon for higher education institutions to schedule learning for certain designated time periods, a limitation that prevents learners from openly and freely accessing learning content whenever they wish or need (Gütl & Chang, 2008). From the perspective of formal education, confining learning content to a scheduled time in a predesignated space hinders the facilitation of lifelong learning for all to a certain degree. As connectedness is a vital characteristic of ecosystems (Pickett & Cadenasso, 2002), online networks with their ability to promote social learning (Brown & Adler, 2008) hold a lot of promise for online learning ecologies. Blaschke et al. (2021) argue that the adoption and implementation of the ecosystem view would serve to facilitate lifelong, life-wide, and life-deep learning, and they define the characteristics of a learning ecology as follows:

- Learning occurs in the chaos and complexity of a system with multiple layers and multiple communication paths and ways of interacting,
- The learning landscape is transitional and in an intermediate state,
- Learning ecologies are constantly evolving and self-organizing, naturally emerging, and distributed as well as complex, highly dynamic, open, self-controlled, and self-maintained,
- Learners are enabled to take control of their own learning process,
- Production and consumption patterns of knowledge are defined according to the self needs of an entity or individual,
- Knowledge is universal, belonging to all shareholders in and out of the ecology,
- The learning authority is defined by the online ecology itself and, therefore, the learning authority is decentralized,

- The learning ecology is open and easy to enter and exit and, therefore, supports widening participation, which can lead to further democratization of education, the liberation of knowledge, and creation of equity for those who pursue knowledge (Blaschke et al., 2021, p. 3)

Siemens (2006) highlights the value of learning ecologies in a networked society and the emergence of new learning ecologies involving online spaces where knowledge is distributed across networks. Bozkurt and Hilbelink (2019) further note that “the new [learning] ecology has online and offline dimensions, and the survival and sustainability of this hybrid ecology depend on still learning approaches” (para. 3). Accordingly, online learning ecologies are not isolated from offline/onsite learning ecologies but are rather part of a continuum, highlighting that learning is a seamless, ongoing, lifelong practice. This notion places the responsibility for facilitating the sustainability of lifelong learning processes with the stakeholders.

The synthesis of the literature suggests that online learning ecologies are spaces where learners can socially interact and communicate with biotic and abiotic entities through a symbiotic relationship. For instance, in an offline/onsite learning ecology, our interactions with abiotic entities involve the use of pens, papers, books, multimedia content (text, sound, images, video etc.), hyperlinks, hashtags, and so on. This means that online learning ecologies are an extension of offline/onsite learning ecologies and lead to a capacity increase in teaching and learning experiences by augmenting our learning experiences. In both ecologies, learners have the opportunity to traverse and cross-pollinate these learning ecologies. In online learning ecologies, learners can form digital identities and represent themselves, which is critical in terms of building social presence and fulfilling the socio-cultural aspects of learning. This indicates that while the infrastructures of online learning ecologies are composed of binary codes, they are complementary to and extensions of our organic offline ecologies, like the two halves of a whole. The characteristics of online learning ecologies further imply their power to build learning communities whose members and learning resources can be globally distributed. Learners in these ecologies can collaborate, cooperate, negotiate, create, share, and interact to enhance the meaningfulness of their learning experiences. Furthermore, learning ecologies provide opportunities for educational institutions to operate beyond the classroom walls and disseminate knowledge across these spaces. Likewise, educators can take advantage of these spaces to facilitate meaningful learning by meeting emerging learning needs, acting more like a facilitator than a transmitter of the knowledge.

4 Online Networked Educational Ecosystems and Openness

Learning is the interaction between the knowing (e.g., learners) and known (e.g., learning resources), and the known should be accessible if we want to liberate information, democratize education, and promote lifelong, life-wide, and life-deep learning (Blaschke et al., 2021). Furthermore, the known should be accessible and barrier free so that the ecosystems can sustain themselves. In this regard, openness plays a critical role in online networked educational ecosystems, and online networks have a significant impact for those who want to access educational content (Brown & Adler, 2008). Accessibility is also significant for the collective development as a global society, because data becomes information, information becomes knowledge when contextualized, and knowledge becomes wisdom through understanding and sense making (Cleveland, 1982; Shedroff, 2001).

Siemens (2005) argues that the "ability to foster, nurture, and synthesize the impacts of varying views of information is critical to knowledge economy survival" (p. 7). This can be seen in the growing importance of a knowledge management system in knowledge ecologies (Büyük & Bozkurt, 2017; Peters, 2009; Siemens, 2005), a system that necessitates giving agency to learners so that they can design and manage their learning processes (Blaschke et al., 2021). Therefore, in providing learners with the opportunity to design their personal learning environments (e.g., a combination of tools, services, and resources to design and control one's own learning process), or personal learning ecologies (Williams et al., 2011), learners are given the agency to survive in their learning ecologies and shape them according to their own learning needs. Another significant element for open online distance education is interaction, which includes learner-learner, learner-instructor, and learner-content interaction (Moore, 1989). In addition to these three types, a fourth type of interaction, learner-interface interaction, was proposed by Hillman et al. (1994). Learner-interface interaction has significance from the perspective of online learning ecologies because our interactions will always require an interface. While all four interaction types are capable of explaining learning, it is important to note that if we want learners to build their personal learning environments, they need to be able to access all the learning content, which includes a vast and increasing amount of knowledge, material, and publications available across online networks. The interaction types and the way they are arranged in our ecosystem viewpoint substantiate the importance of openness and infrastructures, such as repositories where learners can access the

OER. Johnson and Cooke (2016) depict the process of learning in an online ecology as follows:

From an ecological perspective, each learner is unique in terms of a wide range of personal, physical, psychological, and cognitive characteristics. The term bioecology is preferred over terms such as the individual because bioecology emphasizes that each learner is a unique combination of genetic predispositions influenced by microsystemic experience over chronosystemic time. Each unique student influences and is influenced by direct and indirect interactions with all environmental systems (i.e., microsystem, interface subsystem, exosystem and macrosystem). All systems and all e-learners change as a function of time (i.e., chronosystem) (Johnson & Cooke, 2016, p. 16).

Ruppert and Duncan (2017) argue that humans are embedded in ecosystems and benefit from these ecosystems in many ways, and that "these benefits enhance the living conditions of humans and are necessary for the sustainable provision of resources" (p. 752). However, these resources required for sustainability are not always accessible, even though each entity "within an ecosystem has its own ecology within the ecosystem, so the whole is made up of many individual ecologies competing for resources and contributing to the system as a whole, so that the whole system is sustained" (Jackson, 2012, p. 10).

5 Conclusion and Implications: Openness as a Stabilizer of Ecosystems

Learning is unbounded and should not be confined by space or time, as this would act as a barrier to learners' ability to to navigate in learning ecologies and meet their own learning needs. In principle, open learning advocates these features in order to make knowledge accessible and barrier-free for everyone who demands it. Ultimately, the main purposes of these features is to provide an inclusive education as well as to ensure equality and justice. In this context, the idea of openness in education assumes learning to be an ongoing action in line with human development, putting people at the centre of the whole learning process, while the ecosystem view offers a good roadmap for ensuring the sustainability of learning. In an ecosystem, every entity is somehow connected, as is the case in learning. Ideally, learning is a linear, contextual, and situated process characterized by critical reflections, jumps, and disruptions. From this point of view, learning according to ecosystem thinking can strengthen the bonds between formal and informal learning and lead to more meaningful learning. The natures of learning and ecosystems are complex and chaotic, yet complexity and chaos are governed by underlying patterns. Given that, what is the role of openness in education from the perspective of an ecosystem view? The answer is simple; openness provides accessibility, transparency, and democratization, all of which serve to further stabilize ecosystems. To summarize, openness empowers ecosystems, and, in turn, ecosystems amplify openness.

In an ecology, the main cycle is based on producing and consuming. Reproducing and recycling are actions critical to ensuring a sustainable learning ecosystem, and this is where the concept of openness comes in. OEP, for instance, represent the cultures and attitudes, while OER represent *green information* that can be recycled. In an ecology, metaphorically, a seed sprouts, becomes a sapling, turns into a tree, bears fruit, the fruit is consumed, and the seed of the consumed fruit starts its own cycle. Trees are associated with soil, air, and water, they collectively form forests, and when they are collectively united, they have different purposes. The whole process looks complex and chaotic, but it has its own hidden patterns and, eventually, the complexity and chaos produce order. Similarly, in a learning ecology, *green information* is the seed that exists within its own process, completes its own cycle, and serves different purposes. The genesis in our case is the *seed*, as is the *information*, and, therefore, emphasizing the value of being open in many aspects, OEP and OER have greater purposes as they sustain learning ecologies. All in all, as a basic and raw material that is used by other stakeholders in an ecosystem, sustainability of a learning ecosystem depends on how these stakeholders perceive information. As illustrated in the seed metaphor, there is a cycle in producing and consuming continuum, information turns to knowledge, knowledge leads to wisdom, and wisdom generates new data and information bits for advancement, progress, and sustainability. However, it is vital to note that producing seed, i.e., the information, is significant because such an understanding allows each stakeholder to benefit from it (e.g., consuming information) and to contribute to it (e.g., producing information).

Throughout this chapter, the idea of openness in education is explored through the lenses of ecosystems and ecology. From the implications of this exploration, the chapter suggests the following for future research directions: In the theory, there is a need to better understand openness and how the term is interpreted in different cultures. The results would provide the basis for generating global solutions. In practice, while the value of openness is known, its adaptation is slower than expected, which means that the intrinsic and extrinsic motives governing the pursuit of openness by every stakeholder can and should be examined.

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The Role of Institutional Repositories in Higher Education: Purpose and Level of Openness

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Abstract

The aim of this chapter is to consider repositories as distributed learning systems, exploring how they can influence higher education by allowing learners and teachers to deposit their educational resources for open sharing and use in teaching and learning processes. To this end, three essential issues will be addressed. The first is the current state of institutional repositories in higher education at international level. An overview will be offered—covering content, metadata, licences, educational and reuse aspects, etc.—to identify the different levels of development of these repositories, followed by a more specific contextualisation of the European case. The second issue, causally related to the first, is the question of what should be done to (further) increase the level of openness and interconnection of repositories in order to integrate them into education. In other words, how can we advance from open content and Open Educational Resources (OER) to Open Educational Practices (OEP), and from OAI-PHM (Open Archives Initiative Protocol for Metadata Harvesting) protocol interoperability to Linked Data and Open Informational Ecosystems? Finally, several ongoing initiatives will also be discussed as good practice models to be considered.

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1 Introduction

There are two main types of repositories containing Open Educational Resources (OER) in higher education. The first is the OER-exclusive central repository model (national or thematic), and the second is the hybrid model of institutional repositories (IRs) combining teaching and research outputs. There are also web portals called 'referatories' that host links to OER or directories for locating repositories (Neumann & Muuß-Merholz, 2016). Some repositories combine both functions (deposit and referral), such as the Dutch OER Platform Wikiwijs.[1]

OER-exclusive repositories are made up solely of OER collections and are usually national or thematic in nature, often maintained by an associated institution or run by public agencies or private companies. These evolved out of what was formerly referred to as learning object repositories (LORs). Institutional repositories are hybrid platforms, created mostly for storing research outputs although they may also include learning materials. However, there are also some examples of institutional repositories created specifically for educational purposes (e.g., the cooperative repository of Catalan universities MDX -Materials Docents en Xarxa-[2]).

As will be discussed below, both models of repositories have various benefits and drawbacks and, thus, neither is necessarily better than the other. It is the specific context, purpose, availability of resources, and intended outcomes of the OER project concerned that influence the decision of which model to use. Other factors affecting this decision include stakeholder needs, existing institutional policies and practices, technical infrastructure, sustainability, staff skills and understanding, quality workflows, and copyright licensing (Risquez et al., 2020).

In many cases, the existing repository determines the institutional OER strategy and vice versa. This is why many institutions are using their institutional research repositories for the conservation and dissemination of OER. In this way, IRs can support education by encouraging students and teachers to deposit their educational resources and share and use them openly in teaching and learning processes, as well as by providing interconnections with other educational platforms.

With the above in mind, three essential issues will be addressed in this chapter. The first is the current state of institutional repositories in higher education at

[1] https://www.wikiwijs.nl/

[2] https://www.mdx.cat/?locale-attribute=en.

international level. The second issue, causally related to the first, is the question of what should be done to (further) increase the level of openness and interconnection of repositories in order to integrate them into the educational system. In other words, how can we advance from open content to Open Educational Practices (OEP) and from OAI-PHM protocol interoperability to Linked Data and Open Informational Ecosystems? Finally, some ongoing initiatives will be discussed, as good practice models to be considered.

2 The Current State of Institutional Repositories

Overview of OER Repositories

In recent decades, a few types of OER repositories have been widely adopted to advance the aims of the OER initiative as stated in the 2012 Paris Declaration, and to help implement OER as encouraged in the UNESCO (2019) OER Recommendation.

However, there is no single authoritative source listing all OER repositories, and their total number varies depending on the international repository directory consulted. Therefore, it is not clear how many repositories of this kind exist wordwide, and diversity is clearly one of their main characteristics.

According to the OpenDOAR,[3] a directory of open access repositories developed by the University of Nottingham, there are 786 Learning Object repositories[4] (Fig. 1), 89% of which (699) are IRs, while the rest are classified as Disciplinary, Governmental, or Aggregators. This directory shows an exponential increase in the number of institutional repositories over time, which is related to the development of open access policies around the world.

Another important international source, the Registry of Open Access Repositories (ROAR),[5] lists 77 learning and teaching object[6] repositories, most of which are IRs. Finally, the OER World Map,[7] a project funded by the Hewlett

[3] http://www.opendoar.org/

[4] 'Learning object' is the category available in this directory to filter by OER repositories. The number of OER repositories provided is the total as of July 2021.

[5] http://roar.eprints.org/

[6] "Learning and Teaching Objects" is the category available in this directory to filter by OER repositories. The number of OER repositories stated is the total in July 2021.

[7] https://oerworldmap.org/resource/

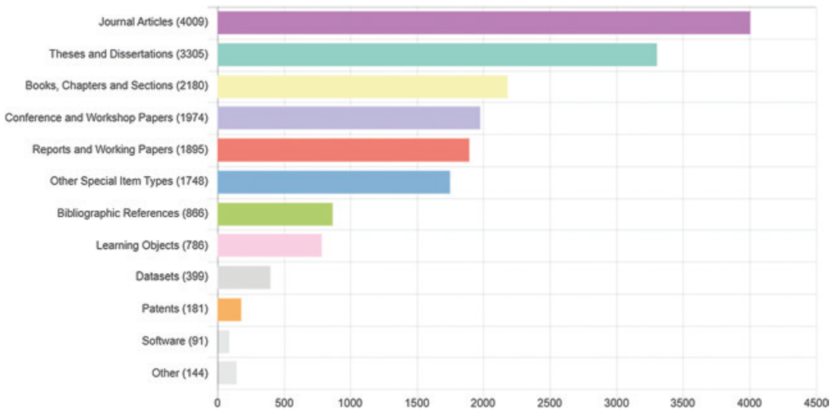

Fig. 1 Open DOAR content types (From Statistics: https://v2.sherpa.ac.uk/view/repository_visualisations/1.html)

Foundation, registers 328 entries of repositories, 125 of which are managed by higher education institutions.

Beyond the numbers, some qualitative studies provide an overview of the state of OER repositories at international level. For example, Tzikopoulos et al. (2007) conducted a pioneering, comprehensive analysis of OER main features, while McGreal (2008) offers a review of the most popular ones. Other global studies include holistic approaches to quality assurance (Atenas & Havemann, 2013; Clements et al., 2015), the promotion of OER through institutional repositories (Castaño et al., 2016), and the state of higher education OER repositories in Latin America (Morales & Montoya, 2014) and worldwide (Santos-Hermosa et al., 2017). Based on this literature, specific characteristics (typology, origin, metadata, quality, licenses, educational and reuse aspects, etc.) can be identified to create a picture of the current state of OER repositories.

Most repositories are institutional (created mainly by universities and government agencies), and the majority are based in the US and Europe (UK, Spain, Germany, and France). The countries with the most repositories appear to be the countries where also the most publications about OER can be found (Zancanaro et al., 2015).

In terms of quality, internal quality assurance (IQA) criteria for repositories have not yet been widely implemented, although some recommendations on the feasibility of incorporating IQA into current and future systems have been offered by experts. The most common top-down criteria seem to be internal assessments (mainly the OER submission process), followed by author prestige and external reviews (peer review systems). Bottom-up quality controls based on community expertise (user ratings and comments) are also used (Clements et al., 2015; Atenas & Havemann, 2013; Santos-Hermosa et al., 2017).

OER repositories are at different levels of development regarding reuse and educational aspects (Santos-Hermosa et al., 2017). Repositories usually include more incentives for reuse, mainly through open licences (most of them using Creative Commons) and social networks, than features that facilitate OER retrieval and use based on educational needs (such as learning objectives). On the other hand, other specific parameters for reuse (such as quality, versioning,[8] granularity, and open formats) are less evident, and only a few categories of educational metadata are offered (generally content type, subject, and educational level).

This situation suggests that repositories focus more specifically on OA licences (allowing different levels of openness) and on facilitating the creation of communities of users (to comment on and share OER) than on providing specific educational metadata. The most common metadata standard used in IRs is Dublin Core (DC), which is not educational but is conditioned by the type of repository software used most (DSpace). However, some cases of metadata crosswalks have also been observed to incorporate LOM (Learning Object Metadata) educational descriptors into DSpace's default-qualified Dublin Core (DC) schema.

European Case

In Europe, apart from the European Commission's communication on 'Opening up education', several national and institutional policies on Open Education (OE) (or with an OE component) promote the development of OER. These also influence the creation and development of better OER infrastructures and, consequently, better repositories.

Some examples (Santos-Hermosa, 2019) at the national level are the cases of Finland (Declaration for Open Science 2020–2025[9,10]), France (second National Plan for Open Science 2021–2024[11]), and Slovenia (Opening Up Slovenia[12]),

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[8] 'Versioning' refers to technical implementations to produce different versions of the same resource.

[9] https://avointiede.fi/sites/default/files/2020-02/Declaration-for-Open-Science-in-Finland-DRAFT_0.pdf

[10] https://avointiede.fi/sites/default/files/2020-02/Declaration-for-Open-Science-in-Finland-DRAFT_0.pdf

[11] https://www.ouvrirlascience.fr/second-national-plan-for-open-science/

[12] Opening Up Slovenia | Opening Up Slovenia Initiative (ouslovenia.net).

while at the institutional level, there are Tilburg University's Action Plan Open Science 2018–2020[13] and Universitat Oberta de Catalunya's Open Knowledge policy 2021.[14] In addition, as mentioned above, there are some European countries with a longer tradition of OER and IR repositories, such as Germany, the UK, France, and Spain.

Although Germany could be characterised as a relative latecomer to the OER scene, there is now a strong OER community in the country. OER are developed in Germany using both bottom-up (the OERinfo and EduArc government funding programmes) and top-down (a national working group for OER repositories) approaches (Orr et al. 2017). In addition, numerous OER portals have been launched in recent years, such as Twilo, ZOERR, or the OER World Map (although this last one is not specific for Germany).

The success of OER repositories in the UK might be due to the OER programme funding support from the Joint Information Systems Committee (JISC),[15] which has supported the development of various OER projects. These initiatives have required records to be deposited in the Jorum open repository and many have also used open institutional repositories to host their original materials (Beetham et al., 2012). However, currently, JISC and Jorum are not active anymore and the OER Research Hub,[16] located in the Institute of Educational Technology (IET) at the Open University (OU), is leading the research on OER and their impact on teaching and learning practices.

Spain also has a specific OER initiative implemented by REBIUN (the Spanish network of university libraries) and launched in 2017, which has been analysing IRs and open policies in terms of educational resources (REBIUN, 2019). A recent study on higher education OER collections in IRs (Santos-Hermosa et al., 2020) has established that there are 45 IRs with collections of this kind in Spanish universities (58.4% of the total) and that there has been an increase in the presence of educational resources in IRs.

Finally, a substantial number of international networks has also been established to promote OER and repositories, such as the SPARC (the Scholarly Publishing and Academic Resources Coalition) Europe[17] and a new working group

[13] https://zenodo.org/record/1182436#.YPhFjOgzZPY

[14] http://hdl.handle.net/10609/130986

[15] https://www.jisc.ac.uk/rd/projects/open-education

[16] http://oerhub.net/

[17] https://sparceurope.org/what-we-do/open-education/

on educational resources within LIBER (Ligue des Bibliothèques Européennes de Recherche – Association of European Research Libraries).[18]

OER Content in Institutional Repositories

An increasing number of universities have chosen their institutional repositories (IRs) for primary access and storage of the OER produced by their faculty, students, and staff. Some of the reasons for using IRs are the existing infrastructure they provide, the possibility of long-term preservation and versioning of OER they offer, their visibility and availability to the academic community, and the benefits in terms of internal promotion and awareness (Ferguson, 2017).

In many cases, the existing IR determines the institutional OER strategy and facilitates compliance with Open Access mandates and policies. This is why some institutions choose their existing institutional repositories of research for OER curation and dissemination. Timing and workflow in ingesting materials are additional considerations that must be factored in, as well as their value as low-cost or no-cost alternatives to open textbooks (Mitchel & Chu, 2014). This kind of repository also has a long lifespan for archiving different updates and editions of an OER (necessary because their modular nature allows instructors to customise materials) and preserving all of them (Hess, 2016).

Moreover, IRs allow institutions to disseminate all their academic production to an external audience but also to the internal community, to make members of that community aware of an OER available that has been created by one faculty member but may also benefit others. Indeed, for an IR to be successful and serve its purpose, it is important that members of the academic community are aware of its existence, understand its value, and are interested in contributing content of their own (Yang & Li, 2015).

Reasons given by OER and IR stakeholders (faculty, librarians, and IR administrators) in support of the suitability of institutional repositories for educational resources include ease of access, sharing and collaboration, and profile enhancement. Faculty also consider that IRs provide protection not offered by other online platforms (ensuring that resources have the proper licensing) and curate resources already shared online (as a form of validation by the institution). Technicians and repository managers also point out that IRs do not have storage capacity problems, allow for multi-object OER deposits, and could provide support for research-led teaching, in the sense that OER might be a type

[18] https://libereurope.eu/working-group/liber-educational-resources-working-group/

of ‘associated material’ to evidence the impact of research on teaching practice (Risquez et al., 2020).

Conversely, arguments against the suitability of IRs for sharing OER mention the availability of other more flexible platforms, lack of visibility, critical mass, the need to keep research and teaching outputs separate, and other concerns such as the lack of a culture of sharing and the need for quality control (Pirkkalainen et al., 2014).

In any case, the success of institutional repositories depends on contributions made by the faculty and students. Similarly, OER are only useful if they are integrated into teaching practices and learning experiences. Therefore, the two workflows need to be brought together: awareness of and commitment to creating and sharing OER (through the repositories); and the use of OER (in classrooms). To achieve this the institution must offer specific training and support (technical, legal, etc.) to engage faculty and students. On the other hand, policies, communication strategies (Tovar Gutiérrez et al., 2014), and interconnected learning systems (Kerres & Heinen, 2015) are crucial for promoting the use of OER in teaching processes through repositories.

3 Integration of Repositories into Education: Openness and Interoperability

According to Ferreras et al. (2013), institutional repositories store, disseminate, and preserve an institution’s digital documents. However, depositing educational resources on a server does not guarantee that they will be effectively retrieved and integrated into classroom learning.

To facilitate the implementation of these educational resources, they need to be open (so they can be used and reused by teachers and learners), described with adequate metadata (so they can be retrieved in accordance with specific educational needs), and exchangeable (by connecting with other technological systems, such as repositories, learning management systems, search engines, and other educational platforms, facilitating interoperability and cross-searchable networks).

For all these reasons, it is important to increase the level of openness, the suitability of metadata, and the interoperability of IRs. Doing so would also promote cross-institutional collaboration and increase the visibility of OER creators.

Finally, once content requirements have been properly ensured, it will be possible to bring practices into the equation, i.e., introduce Open Education Practices (OEP) that support the (re)use and production of OER into teaching and learning.

3.1 Openness: From Open Content to Open Educational Practices (OEP)

Openness in education has attracted considerable attention and discussion in recent years. However, it is a complex concept, subject to different interpretations (openness as free access, openness as open licensed resources, openness as open educational practices, etc.) and with various related elements (OER, MOOCs, OEP, co-creation, networked participation, etc.). This section attempts to identify the best possible way of depositing OER into IRs (content) for implementation and use in teaching (practices).

There are many reports that stress the importance of open licences for OER use. The Paris Declaration (UNESCO, 2012), for instance, promotes open licences 'in order to facilitate the use, reuse, revision, combination, and redistribution of educational materials worldwide'. Furthermore, various international guidelines (Butcher, 2011; Conole, 2011) and research by the Commonwealth of Learning (McGreal et al., 2013) exist, which demand the use of Creative Commons licences and open standards as a precondition for the educational use of OER. However, other critical approaches to open education broaden this perspective and encourage a view that moves beyond the binaries of open and closed (Cronin, 2020).

The widespread adoption of Creative Commons licensing and the sense of public ownership of resources and content developed with public budgets are helping to foster openness. In the case of IRs, studies show that the openness of deposited OER has been increasing over the years regarding the number of resources with a CC license (Tzikopoulos et al., 2007; Atenas & Havemann, 2013; Amiel & Soares, 2016; Santos-Hermosa et al., 2017; Santos-Hermosa et al., 2020).

Although institutional repositories can provide OER for use in the classroom and pedagogical development, there are still two important considerations regarding open licensing that need to be taken into account for the successful implementation of OER. The first has to do with identifying the most appropriate licences for OER, while the second is related to opening up education through OEP.

One of the main concerns of teachers when sharing resources in repositories is the loss of ownership control (Risquez et al., 2020). Related to this, when looking for OER by other authors, teachers also need to know the legal conditions under which a particular resource can be used in their classroom. Therefore, in order to use and reuse OER, teachers need training and advice so that they will be able to choose suitable licences for their own material and recognise the licences on other colleagues' resources.

In this sense, librarians are doing an excellent job of supporting faculty and advising them about copyright, open licences, and permissions, for example, through OER toolkits and other specific services (West et al., 2018). However, especially in relation to IRs, administrators have been dealing with research outputs for a long time and although there is a workflow in the research domain (definitions for peer-review, copyright, quality control, etc.), they do not usually have clear guidelines for OER. It is also true that there is no general agreement or criteria on when and how OER are suitable for teaching and learning, e.g., when a resource has reached a quality that is acceptable for sharing or how to recommend the most appropriate open licence for an OER (REBIUN, 2019; Risquez, 2020; Santos-Hermosa et al., 2020).

However, some steps towards international collaboration have been taken, and OER librarians organise themselves in networks, such as the European Network of Open Education Librarians (ENOEL)[19] in SPARC Europe and a recent Group on Educational Resources in LIBER.[20]

Regarding the question of opening up education, it is important to highlight that the increasing number of OER repositories and the availability of (many) open license educational resources will not necessarily suffice to achieve. The proliferation of OER alone will not change educational practices and will not automatically improve the quality of education (Knox, 2013). Open education is more complex and should include practices that support the reuse and production of OER through institutional policies, promote innovative pedagogical models, and respect and empower learners as co-producers on their lifelong learning paths (Ehlers, 2011). Wiley and Hilton (2018) even propose a new term as a reaction to the development of Open Pedagogy ideas, 'OER-enabled pedagogy', defined as the set of teaching and learning practices that are only possible or feasible with the permissions that are characteristic of OER. In this sense, it is necessary to support innovative approaches to teaching and learning and expand participation in education, not only by facilitating access to content but also by creating open communities of practice (Cronin, 2017).

[19] https://sparceurope.org/what-we-do/open-education/europeannetwork-openeducation-librarians/

[20] https://libereurope.eu/article/call-for-members-new-liber-working-group-on-educational-resources/

3.2 Interoperability: From OAI-PMH to Linked Open Data and Open Informational Ecosystems

In addition to making openly licensed resources available and facilitating their use in teaching, repositories should include proper educational metadata and be connected to other repositories, educational platforms, and LMS. All this is needed to build federated systems of networked platforms and to establish open informational ecosystems.

Metadata

Repositories require an efficient search mechanism based on metadata in addition to intuitive navigation, quality controls, etc. According to Atenas and Havemann (2013), metadata is an indicator of quality assurance and a prerequisite for a repository's success.

Thus, an excellent metadata-based strategy has positive effects on using a repository for both educators and students (in terms of achievement and dropout rates). For example, the description of OER using specific educational metadata generally receives a positive response from users, since they recognise that just using the title, keywords, and type of resources is not enough to find suitable OER (Wojcik & Rataj, 2020). On the other hand, the inability to use repositories effectively to find content that meets the needs of potential users (educators, students, etc.) can inhibit the broader adoption of these platforms and prevent them from having greater impact on open education (Dichev & Dicheva, 2012).

In this sense, the use of metadata standards (such as IEEE LOM[21]) facilitates the description of didactic characteristics of the OER (educational level, learning objectives, competencies, etc.) that are essential for retrieving and using them in accordance with the teaching and learning purposes of the users (Santos-Hermosa et al., 2017). It is also recommended that educational metadata be enriched with ontology-based semantic indexing for better results (Ruiz-Iniesta et al., 2014).

Artificial Intelligence

In the last few years, artificial intelligence (AI) and machine learning (ML) have become ubiquitous terms. They are applied to solve existing problems as an increasingly popular practice and should be considered for problems emerging in the future (Gonzalez, Zimmermann & Nagappan, 2020).

[21] https://standards.ieee.org/standard/1484_12_1-2020.html

Machine learning algorithms require access to large amounts of data and metadata from multiple, cross-linked files, which should be easy to consult and retrieve the correct information from (Prior et al., 2020). Such approaches can complement repositories' discoverability. For example, the role of AI in automatic metadata generation and machine learning extraction methods is expanding the possibilities for OER search (Tsay et al., 2020).

OAI-PMH Interoperability

Interoperability plays a crucial role in the sharing and global discovery of content in the education environment. Driven by the open access movement, the interoperability of metadata has been the most active area in developing digital repositories (Aschenbrenner et al., 2008).

The OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting), developed by the Open Archives Initiative, is based on open standards that guarantee automatic interoperability between senders and receivers of digital resources. Most institutional repository software providers (such as DSpace, EPrints, Digital Commons, etc.) support Dublin Core metadata export and use OAI-PMH to allow interoperability with other repositories to harvest bibliographic data (OAI, 2015). The repositories are constantly fed with new description metadata and send their own to one another. This perpetual activity of search queries allows continuous updating of these platforms.

Although OAI-PMH is a well-established and widely-used standard that facilitates the exchange of metadata, it still has some problems when integrating data that is extracted from various repositories, and its use for OER is somewhat limited.

OAI-PMH has difficulties to standardise standardising processes for the description and publication of metadata in the open environment of the web, resulting in a heterogeneous context in which each institution individually manages various metadata schemas, data formats, or vocabularies. Therefore, this metadata standard achieves only the lowest level of interoperability in repositories by facilitating the extraction and exchange of metadata. However, it does not ensure the reuse and integration of information since it does not have the possibility of unification and interoperability with other datasets (Piedra et al., 2014). Therefore, OER data should be encoded in a machine-readable format to be easily accessible to any user (human being or machine agent) and, thus, improve the exchange, reuse, sharing, and enrichment of data.

In recent years, it has been generally noted (OpenAIRE, 2021) that some customisations and significant advances have been made in IRs concerning enriching metadata (through mechanisms to adapt the DC to specific information needs) and extracting and recovering useful information for users, as well as the processing of meaning (semantics of information). However, in the European context, most institutional repositories are currently focusing on improving scholarly communication and research resources.

This is evidenced by the Confederation of Open Access Repositories (COAR) initiative named Next Generation Repositories (NGR), which identifies protocols and technologies that will enable new and improved functionalities for 21st-century repository systems. The initiative aims to support interconnected, resource-centric repositories that manage access to diverse outputs, making resources the focus of services (Rodrigues et al., 2017).

Although the most recent NGR reports (COAR, 2019; Rodrigues et al., 2017; Walk et al., 2020) advocate moving towards new levels of web-centric interoperability and web technologies and also recommend keeping repositories open to new kinds of content (such as OER), they are still focused mainly on the development of technologies that will enhance research outputs.

Recent advancements include review services for repositories, which enable the linking of preprints and other repository resources to external services (Walk et al., 2020). Another advancement is the technology Signposting,[22] an approach to informing machine agents about the nature of the resources linked to the resource they currently interact with. Finally, ResourceSync[23] is a mechanism for large-scale synchronising of web resources, allowing aggregation services to 'harvest' metadata and content from repositories (OpenAIRE, 2021).

All these improvements focus on research outputs and the connection of several different platforms in scholarly communications (by creating gateways between IRs, data repositories, preprint servers, publishing platforms, CRIS systems, etc.). In addition, some of these refinements have been integrated into widely used institutional repository platforms (Ferreras, 2021).

Nevertheless, it seems clear that they are not yet oriented towards OER or educational ecosystems and that a more specific approach needs to be developed. There are two main challenges in this respect: integrating OER into IRs using semantic web technologies and Linked Open data and connecting different open information systems (repositories, LMS, and other educational platforms) in an educational ecosystem.

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[22] https://signposting.org/

[23] http://www.openarchives.org/rs/toc

Integration: Semantic Web and Linked Data

The integration focus facilitates the combination of existing information resources in various contexts. Semantic web technologies and, specifically, linked data (referring to connecting structured data on the web) change the way information is stored, published, connected, and exploited (Berners-Lee, 2006).

When applied to IRs, this creates the potential for global networks of cross-searchable information. Networked repositories lower access barriers and offer the widest possible dissemination of content (Ukwoma et al., 2019). This is why there is a need to improve the metadata interoperability between different collections of open material through the application of a semantic web approach and linked data technologies.

An example of a repository pursuing this kind of development is MIIDAS, in the areas of computing and electronics, which includes the metadata of the OAI-PMH protocol and adds educational metadata. This platform uses the Resource Description Framework (RDF), ontologies, and SPARQL query language to improve resource retrieval (Durán & Ramírez, 2021). This kind of development in IRs is disseminating OER and allowing the construction of semantically enriched data sets. Another case of using linked data technologies for open access repositories to optimise the level of interoperability is the network of repositories belonging to the Ecuadorian Consortium for the Development of the Advanced Internet (CEDIA)[24] (Piedra et al., 2015).

Open Informational Ecosystems

Technical discussions have evolved from the fundamental issues of creating repositories connected through interoperability protocols to the integration of repositories into a broader academic infrastructure (COAR, 2015; Rodrigues et al., 2017).

To avoid a situation where repositories behave like local silos, the repository infrastructure needs to evolve rapidly and interact with other local infrastructures and external systems that facilitate education (such as collaborative teaching environments, e-learning systems, editorials, etc.). There is a need to extend interoperability activities beyond repository-to-repository efforts to include interoperability across the diversity of systems that exist in the educational context.

When IRs go beyond merely providing content and offering systematic exchange with different external platforms, they become 'open informational

[24] http://www.cedia.org.ec

ecosystems'. According to Kerres and Heinen (2015), these systems are defined as a technological infrastructure of related services, in which several independent providers are linked and their collaboration relies on standards for interfacing content and metadata.

Open information systems consist of a reference platform that provides access to all associated content platforms. An example is the publicly financed German educational server Deutscher Bildungsserver,[25] which acts as a reference platform that links to private and public content providers with (open and closed) learning materials for primary and secondary education. In addition, this server is linked to the reference-run platforms of the 16 German states and supports connections between state education servers to develop technical, informational, and editorial infrastructures.

Other examples of OER integration between heterogeneous learning platforms—specifically regarding the connection of repositories with learning management systems (LMS) and MOOCs—are discussed below.

Some preliminary steps towards building bridges between learning systems were taken by the Massachusetts Institute of Technology (MIT) when it created an open source e-learning platform called .LRN (dotLRN), which integrated different services in the virtual learning environment (including OER repositories). The MIT also defined a global e-learning strategy, named Intellectual Commons, that includes .LRN and its other initiatives (Sotelo et al., 2019).

The DSpace software for IRs has also been integrated into the Moodle LMS using various plugins (Gómez et al., 2014), a search engine (Guzman-Arias et al., 2019), and online laboratories (Ruano et al., 2020). One plugin performs the integration using the permanent URL (or handle) provided for the DSpace software to every item (file), which allows the incorporation of OER from the repository into the virtual classroom in Moodle. The Open Education Austria Advanced project[26] has developed another OER plugin that makes it possible to index OER in the LMS (Moodle) with the corresponding OER metadata, to transfer them into the university's repository, and to make them available via other services, such as the Austrian OER portal (Ruano et al., 2019). A different strategy is to enable access to OER using the institution's own LMS and offering it to a wider public via the university's own OER repository, as Graz University of Technology (TU Graz) has done (Ladurner et al., 2020).

[25] www.eduserver.de

[26] https://www.openeducation.at/

Other institutions establish interactions between formal and non-formal systems (e-learning and MOOC platforms) through frameworks based on linked data technologies and integration layers that allow MOOC designers to find and access OER in repositories (Mrhar et al., 2020).

Through such initiatives to integrate different platforms into open information ecosystems, the gap between educational resources and educational systems can be filled, resulting in an immense contribution to open education.

4 Current OER Repository Initiatives

This last section considers some interesting ongoing initiatives involving OER repositories. Some of these initiatives have been chosen because they create global, international, or national informational ecosystems (such as 5Xgon, Open Discovery Space, or ENCORE+), while others provide a connected national infrastructure (OERSi and Open Education Austria). However, all of them have in common that they seek ways to influence the future of open educational resources by applying the latest technologies to the educational ecosystem.

OERSI

The Open Educational Resources Search Index (OERSI)[27] is a central entry point for OER searches in higher education in Germany across distributed heterogeneous sources. It is a new repository created by the Technische Informationsbibliothek (TIB) in Hannover under the responsibility of the Ministry for Science and Culture of Lower Saxony (Van Wijngaarden et al., 2021). It has been developed with reusable open-source software, whose code is available on GitLab.[28] The search sources are various OER portals and repositories and the OER that can be accessed are mainly videos, although there are also courses, images, etc. The target groups are end users (teachers, learners) and service providers (repository operators, LMS operators).

Its technical features include standardised JSON-LD metadata[29] based on the Learning Resource Metadata Initiative (LRMI), schema.org, and SKOS; a Modular ETL (Extract, Transform, Load)[30] for import processes, and an option for

[27] https://oersi.de

[28] https://gitlab.com/oersi

[29] https://json-ld.org/

[30] https://en.wikipedia.org/wiki/Extract,_transform,_load

embedding OER in LMS or other contexts. Thus, the OERSI can be considered an open infrastructure good practice for connecting distributed scenarios.

Open Education Austria

Open Education Austria Advanced (OEAA)[31] is a project by Austrian universities (running from 2020 to February 28, 2024) to jointly develop a national infrastructure for OER. It is a specialist portal with a search function across the decentralised OER repositories provided by the participating universities, e-learning centres, and central computer science services. Its modular system architectures and open-source software developments facilitate universities' (technical) participation beyond the project. The project is also working on establishing an open source repository and implementing interfaces with university-owned services. Furthermore, the definition of an application profile based on LOM facilitates metadata transformations, thus enabling OER outside local repositories and the specialist portal.

OEAA is also conceived as a good practice in cross-institutional open-source development that aims to contribute to the unrestricted use of OER by gradually establishing open practices analogous to research (Open Access, Open Data). It also provides training and a national OER certification body, operated by the Forum for New Media in Teaching Austria (FNMA).

5XGon

The X5Gon[32] is a cross-site global OER network that aims to connect European OER repositories. Its database contains OER from registered OER repositories in its network of 22 partners (including MIT OCW, University of Bologna, and others). The materials currently shown are three types of OER (text, video, and audio) that have been enriched through wikification.[33]

The indexed OER platforms are connected in this network via the Connect service and APIs. This is made possible by adding a JavaScript code snippet to each resource to be indexed (and enriched with transcription and translation when needed), which will itself call a library on the own server.[34] Concerning OER

[31] https://www.openeducation.at/

[32] https://platform.x5gon.org/

[33] The application of wiki markup to text (https://en.wikipedia.org/wiki/Wiki#Editing).

[34] More details at: https://www.x5gon.org/about/connect/

aggregation services, it has been decided to develop an option that also connects with the OAI-PMH protocol.

Other RTD projects related to X5Gon technologies include lecture recording solutions (the VirtUOS platform[35] run by Osnabruck University), transLectures (TraMOOC and Videolecture repository[36]), and RTD projects[37] related to MOOCs (Polimedia at Universitat Politècnica de València[38]).

X5Gon is an interesting case of merging services and developing technologies that constitutes the stepping stone towards a wide range of derivative applications in educational technologies. It is also working on adapting new solutions for near real-time multilingual delivery of OER content and MOOCs, since coverage of under-resourced languages is needed.

ENCORE Projects

The European Network for Catalysing Open Resources in Education (ENCORE+)[39] is part of the 2020 ERASMUS+ programme and responds to the European priority of opening up education. One of its five main objectives is to foster the collaboration and connection of repositories in a European OER repository ecosystem. A working package (WP3) named 'Technology for the Future European OER Repository Ecosystem' is currently working specifically on this aim. The first deliverable will be a proof of concept of key features of the OER infrastructure, identifying and exploring key technological features of OER repositories to support quality assured production, sustainability, and innovation.

The International Council for Open and Distance Education (ICDE) is the coordinator of the project, which also includes several institutional partners, such as the Open University in the United Kingdom, Universidad Internacional de la Rioja in Spain, and Dublin City University in Ireland. The private sector is also represented among the project partners by Joubel AS in Norway, and Knowledge 4 all Foundation and Instructure Global Ltd. (Canvas) in the United Kingdom.

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[35] https://www.x5gon.org/casestudy/osnabruck-university-use-case-virtuos/

[36] https://www.x5gon.org/casestudy/video-platform-use-case-videolectures-net/

[37] Specific programmes of the European Community's Third Framework Programme for research and technological development.

[38] https://www.x5gon.org/casestudy/universitat-politecnica-de-valencia-platform-use-case-polimedia/

[39] https://www.k4all.org/project/encore/

ENCORE+ seems to be very timely in view of the newly adopted UNESCO (2019) OER Recommendation, and it offers a new vision for collaboration and connection between OER repositories in a European OER Ecosystem, encouraging entrepreneurship and empowerment through OER.

5 Conclusion

The Covid-19 pandemic has reinforced the general need for OER in all educational sectors. Undoubtedly, repositories play a vital role in this regard since they improve and facilitate access to OER. The overview presented here shows the increasing number of OER collections, their presence in institutional repositories (IRs), and their different levels of development. We can also conclude that for greater adoption of OER, more effectiveness is needed in the search and location in the IRs and more interoperability with the other educational platforms of an institution.

As we have seen, a variety of actions is needed to turn repositories into distributed learning systems. On the one hand, repositories should take advantage of emerging technologies in terms of cross-searchable information, with semantic web and linked open data increasing discovery and findability, and artificial intelligence and machine learning supporting this. Therefore, a good combination of both human and computer access methods should be considered in future. On the other hand, increasing the openness of OER is also a good way since the open licence allocation allows the actual reuse and remix of OER.

Last but not least, strong institutional coverage should be provided, with strategies top-down and bottom-up, to establish a culture of sharing and OER adoption in teaching and learning. Examples are amplifying and promoting the adaption of OER through institutional policies, strategies, and incentives and providing technical and infrastructural standards for the construction and design of OER repositories. Other complementary strategies are increasing awareness and training for practitioners and teachers in open skills and open education methods since many of them are not yet familiar with the term OER. Accompanying and tutoring faculty and students on their path to OER, with some practice in sharing them in repositories and using them in established pedagogical approaches, would be possible strategies to implement.

OER is on the road to mainstream acceptance, and a mix of strategies to stimulate their adoption through repositories should be applied, embracing all relevant stakeholders within institutions.

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Typologies of (Open) Online Courses and Their Dimensions, Characteristics and Relationships with Distributed Learning Ecosystems, Open Educational Resources, and Massive Open Online Courses

Christian M. Stracke, Aras Bozkurt and Daniel Burgos

Abstract

This chapter analyses the different typologies of online courses. First, we start with a reflection about the key terms of online learning, online courses, and distributed learning ecosystems (DLE). In our literature review, we cannot identify any existing typology framework for online courses. Consequently, we analyse and compare dimensions and categories of online courses from different sources: first, from the collected publications and studies identified in our literature review, second, from the current practices and platforms for online courses, and third, from standards for online courses, including the first international quality norm for online learning ISO/IEC 40180. As our key result, a framework proposal for the different typologies of online courses

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is developed based on these discussions and a comparison of several dimensions. The integration of our comparison results leads to the Typologies of Online Courses (TOC) framework with eight dimensions. The aim of the TOC framework is two-fold. First, it should support designers in the design, quality development, and evaluation of online courses. Second, it should enable learners to differentiate online courses according to the dimensions of these courses in comparison with their own preferences and demands. In the conclusion, an outlook on future research needs is provided. Finally, we come full circle and briefly discuss how (open) online courses and especially the two currently most important types, namely, Open Educational Resources (OER) and Massive Open Online Courses (MOOCs), can contribute to DLE and to addressing the general need for (equity and collaborative) education for all.

1 Introduction

In this chapter, we analyse the contribution of online courses to distributed learning ecosystems (DLE) and introduce a typology of online courses for their categorisation and description. In recent years, particularly during the coronavirus (COVID-19) pandemic and its associated lockdowns, DLE have attracted increasing interest and grown in importance. Schools and universities have had to close their buildings and suspend traditional modes of providing formal education. Distance and online learning has become the new normal for many teachers and students. To facilitate emergency remote education, DLE have been established in diverse and often hasty ways. Consequently, teachers and public authorities have identified the need for related capacity building and competence development as well as for appropriate (digital) content and education. Technological and pedagogical competences are required for the design and accomplishment of distance and online learning.

The starting point for our discussion of the different categories of online courses and their dimensions is to reflect on the following key terms and their definitions: online learning, online courses, and DLE. Based on this reflection, we present the results of our explanatory literature review. Then, we analyse and compare the current practices and platforms used to deliver online courses. Furthermore, we present and compare the relevant standards and norms used in online learning and courses. The integration of our comparison results leads to our proposal for a Typologies of Online Courses (TOC) framework with eight dimensions. The aim of the TOC framework is two-fold. First, it should support designers in the design, quality development, and evaluation of online courses.

Second, it should enable learners to differentiate online courses according to the dimensions of these courses in comparison with their own preferences and demands. In the conclusion, an outlook on future research needs is provided. Finally, we come full circle and briefly discuss how online courses and especially the two most important types, Open Educational Resources (OER) and Massive Open Online Courses (MOOCs), can contribute to DLE and to addressing the general need for (equity and collaborative) education for all.

2 Online Courses and DLE

Online courses and DLE currently attract great attention and face an increase in demand and application. This is, particularly due to the COVID-19 pandemic.

2.1 Online Learning as the 'New Normal'

The COVID-19 pandemic has affected all countries and societies worldwide, including their education systems (World Health Organization, 2020). The direct impact has been unique, especially on formal education, as described and analysed in the first reports of such global organisations as the United Nations (2020), the Organisation for Economic Co-operation and Development (OECD, 2020, 2021a, b), and, in particular, the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2020, 2021), also in collaboration with the United Nations Children's Fund, The World Bank, and OECD (UNESCO et al., 2020, 2021). In many regions and countries, the sudden lockdowns and varying social distancing measures have led to an immediate shift towards online distance education without any experience, guidelines, or training in most cases (UNESCO, 2020, 2021). Progressively, online learning has become the new normal in school education (also called K-12) and higher education, increasing the inequity and digital divide between privileged and marginalised individuals (teachers, students, and students' families), rich and poor populations, social groups, and developed and under-developed regions and countries (UNESCO et al., 2020, 2021). Currently, under the COVID-19 pandemic, online education is at least partially gaining a potential to be a new normal (and during lockdown periods often the only full-time solution) (Stracke et al., 2021). Therefore, it is crucial to analyse how online courses as the central element and mode of online learning can support and facilitate such online education as the potential new normal in schools and universities.

2.2 What are (Open) Online Courses?

We define the term 'online course' in its broadest sense through three key characteristics: any type of learning that (1) takes place online, (2) is designed with learning objectives and intentions (i.e., as formal education), and (3) is limited to a time period (i.e., a specific duration or has a start and end time). The first condition excludes face-to-face and any type of hybrid (so-called 'blended') learning, the second condition differentiates an online course from non-formal and informal learning, and the third condition distinguishes online courses from general online learning that can take place, for example, in open communities without any time constraints and limitations (a specific duration is the core part of a course concept). Further educational dimensions are not distinctive for online courses. With regards to synchronicity, online courses can happen synchronously and asynchronously (and in any combination of both). With regards to guidance, online courses can be educator-led or self-directed (and any combination of both). With regards to cooperation, online courses can be designed for collaborative or single learning (and any combination of both). Finally, open online courses are a subset of all online courses: 'open' in this context means more than free and easy (open) access to courses— it means a philosophy of openness in the pedagogical design, implementation, and achievement of the online learning opportunity, facilitating self-responsible, collaborative, and non-hierarchical learning experiences.

2.3 Relation Between Online Courses and DLE

DLE transfer the concepts of ecosystems (Bronfenbrenner, 1979) and social constructivism (Luhmann, 1995) to learning scenarios and processes (Blaschke et al., 2021; Gütl & Chang, 2008). As a generic term, 'DLE' might stand for a synonym of any kind of distance education as it requires (as a minimum condition) at least two distributed individuals (this could be learners and teachers) at a distance and who are building a learning ecosystem. These minimum requirements are the same for any distance learning (Ruppert & Duncan, 2017). In this view, online courses would be special cases and a sub-group of DLE. However, DLE is normally defined as and connected to specific types of distance learning, namely, collaborative learning in communities and online (Blaschke et al., 2021). From this perspective, online courses can be considered theoretically as a generic umbrella term that includes all DLE with formal learning objectives. In this chapter, we use this latter definition of DLE to emphasise the communication, exchange, and collaborative aspects of DLE for online learners and educators. This dynamic aspect of DLE is also characteristic of open courses.

3 Typologies and Dimensions of Online Courses

For the identification of the dimensions of online courses, we started with an explanatory literature review.

3.1 Review of Literature on Online Courses

We conducted a literature search using the Web of Science Core Collection as the main database for scientific articles. Surprisingly, the search string on title entries "((TI = ("online cours*")) AND (TI = (typolog*)))" resulted in only one article. The broader search string "((TI = ("online cours*")) AND (TI = (typ*)))", which allows also type or types as results, produced only four articles. Therefore, we decided to broaden our search strategy. We included keywords leading to 23 articles as results for ((TS = ("online cours*")) AND (TS = (typolog*))). Furthermore, we used additional search terms that are directly connected to online courses such as 'design', 'quality', and 'evaluation' and applied the snowball approach—that is, we additionally analysed the references from the most beneficial articles.

For face-to-face (on-site) education and courses, Merrill (2002) created five basic methods and learning principles (problem-centred, activation, demonstration, application, and integration) and introduced three requirements of instruction, namely, it has to be effective, efficient, and engaging (Merrill, 2009). Based on a theoretical analysis of four main educational philosophies, namely, instructionism, constructionism, socio-cultural learning, and collaborative learning, Laurillard (2009) developed a conversational framework with guiding questions for designing (collaborative) online learning. She considered collaborative learning to be a key opportunity offered by digital technologies and courses. In addition to the three traditional interaction types, which are learner-to-learner, learner-to-teacher, and learner-to-content, as originally defined by Moore (1989), online learning enables a fourth interaction type (group-to-group interaction), and the latest research by Stracke et al. (2018a) highlights the high importance of all four online interaction types.

In a review study, Kebritchi et al. (2017) analysed the issues and challenges facing or online courses in higher education, and recommended the integration of multimedia, peer collaboration, online tutorials, automated feedback, discussion groups, and learning communities when transitioning from face-to-face (on-site) to online courses. Baldwin et al. (2018b) compared six guidelines and rubrics for designing high quality online courses to identify commonalities, which were then used by Martin et al. (2021) for the development of the Online Course Design Elements instrument. The Asian Association of Open Universities (2020) published the quality assurance framework, without giving any information about its development. The European Commission has developed several initiatives and guidelines around digital learning and online courses, including the Digital Education Action Plan (2021 to 2027) and, most recently, online consultations on digital education and micro-credentials (European Commission, 2020).

Most relevant to our research objectives is the European initiative for quality and massive open online courses, also called MOOQ (http://mooc-quality.eu). The initiative focuses research on open online education and analyses current practices revealing great differences between the expectations of online learners and what is produced by designers of online courses (Stracke et al., 2018a). Based on the findings from the Global MOOC Quality Survey and the involvement of thousands of MOOC learners, designers, and facilitators in many iterative cycles (Stracke & Tan, 2018), the Quality Reference Framework (QRF) for the quality of MOOCs (see Fig. 1) was developed as a globally representative instrument (Stracke et al., 2018b). QRF distinguishes five dimensions (presented in Fig. 1) that must be addressed for the design, quality, and evaluation of online courses; namely, analysis, design, implementation, realization, and evaluation. The elements of the five dimensions cover the full range of potential options for online learning and courses; thus, they are not mandatory, but they need to be selected according to the given learning objectives and situation (Stracke et al., 2018b).

Furthermore, QRF contains the QRF Quality Checklist with guiding questions for beginners in (taking or developing) online education as well as the QRF Key Quality Criteria with the full list of potential quality criteria for designers and experts in online education.

As a first result from our literature review, we can conclude that a precise typology and specific, commonly agreed dimensions for online courses cannot be found in the literature; this denotes a research desideratum. Comparing the QRF with the analysed literature, we can only conclude that some dimensions can be considered a minimum as they are mentioned in almost all scientific publications and in the QRF structure—these dimensions are analysis, design, implementa-

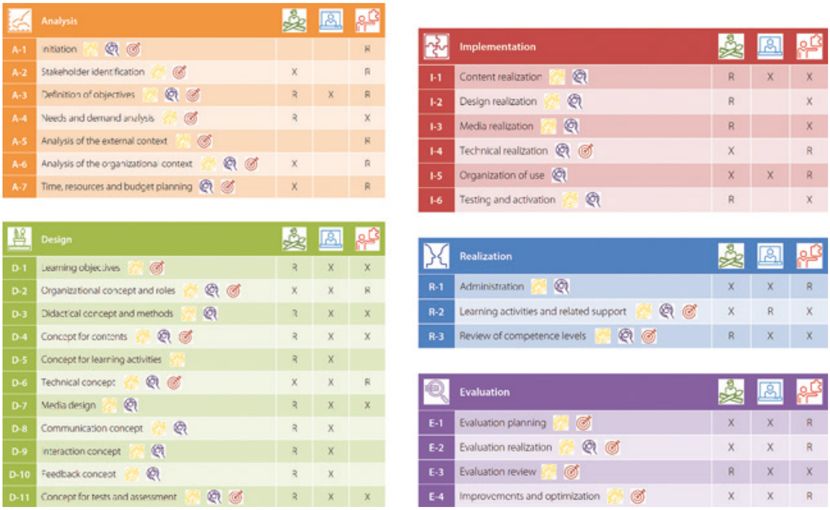

Fig. 1 The Quality Reference Framework (QRF) (Stracke et al., 2018b)

tion, realisation, and evaluation. In the following section, we will enrich our analysis and compare the current practices and platforms offering online courses.

3.2 Online Courses: Current Practices and Platforms

Since the 2000s, online learning and courses have become increasingly popular and mainstream especially in higher education (Garrett et al., 2020). However, interviews by Baldwin et al. (2018a) have revealed that designers of online courses often simply followed the principles of the traditional (face-to-face or on-site) ADDIE model, which refers to the five phases of analyse, Design, Develop, Implement, and Evaluate. This is considered a limitation. Designers of online courses differ from designers of face-to-face courses as they set different priorities—they value and facilitate interactions amongst learners but often do not address special needs and do not offer self-assessment (Bolliger & Martin, 2021). Nevertheless, broad and, especially, longitudinal studies on online learning and courses are still missing although they are much sought after. Thus, we will summarise the current practices through an overview of various platforms offering online courses that claim to be lead in terms of the number of courses, learners, and quality.

The online platform Class Central is, according to its advertising, the biggest online search engine platform for MOOCs ('The #1 Search Engine for MOOCs'). It lists more than 40,000 online courses, but the courses can only be selected and filtered according to basic categories: subjects, providers, rankings, and (self-curated) collections (Class Central, 2021). Udemy lists more than 183,000 online courses according to its own promotion, but it specialises in offering only video-based courses. When searching Udemy, you can select only by topic (only a single category is offered); but within that topic, you can select from several categories: levels, languages, prices, features (consisting of a diverse mixture of categories, namely, subtitles, quizzes, coding exercises, and practice tests), ratings, video duration, and (foreign) subtitles (Udemy, 2021). edX (2021) offers more than 3000 online courses and follows the same structure. You can choose only from subjects listed on the start page (plus direct links to programmes and providers in the top navigation) but, subsequently, you can select from several categories in the search results (subject, provider, programme, level, language, availability, and learning type). Coursera does not explicitly state how many courses it offers, but its latest impact report states there are more than 5000 (Coursera, 2021). Coursera has established a similar structure to that of Udemy: on its landing page, you can directly search all courses or choose links to providers, certificates, degrees, skills, free courses, and subjects (plus direct links to goals and subjects in the top navigation), while in the search results, you can select from several categories (language, level, duration, subject, skill, partner, and learning product). Other platforms providing online courses offer even fewer categorisation and filter options than the platforms listed above. In MOOC List, you can only search for subjects and formal conditions (MOOC List, 2021). The private provider FutureLearn (2021), which formerly belonged to UK's Open University, differentiates only between sizes of online courses: 'Short courses', 'ExpertTracks', 'Microcredentials and programs', and 'Online degrees'. Fordham University (2021), as an example of a private university (with the highest Google ranking), distinguishes only between three modes: asynchronous online, synchronous online, and hybrid courses (also known as blended).

In Table 1, we compare definitions and categorisations of online courses that are used by online platforms to differentiate the online courses offered.

It is obvious that the online platforms use different terminologies and numbers of categories. They mainly distinguish the online courses by content (whereby

Table 1 Categories of online courses differentiated in online platforms

	Class Central	Udemy	edX	Coursera	Khan Academy	MOOC List	FutureLearn	Fordham University
Objectives				Goals				
Target group		Levels Languages (Foreign) subtitles	Program Level Language	Skills Language Level	Levels Languages (Foreign) subtitles	Formal conditions		
Pedagogies			Learning type					Modes
Content	Subjects Collections (self-curated)	Topics Duration Price	Subject Availability	Certificates Degrees Subjects Duration Learning products	Topics Duration	Subjects	Sizes	
Assessment		Quizzes Coding exercises Practice tests			Quizzes Coding exercises Practice tests			
Context	Providers	Price	Providers/ Partners	Free courses Providers/ Partners	Price			
Evaluation	Rankings	Ratings			Ratings			

subjects or topics are addressed as well as content size or duration) and focused target groups (the levels and languages addressed).

Surprisingly, online platforms do not use categories related to design and technologies to distinguish their offered online courses. Furthermore, the categories related to objectives (only once) and to pedagogies (only twice) are not often used. It seems that categories of educational dimensions and didactics are not important for online platforms, which is in stark contrast to the scientific literature and studies. In the following section, we change our perspective again to further broaden our comparison by introducing and analysing existing standards and norms that are relevant for online learning and courses.

3.3 Standards and Norms for Online Learning and Courses

There is a mix of terminology related to norms, standards, and guidelines. To avoid this confusion, we distinguish between norms developed by de-jure and legitimated standardisation bodies, standards developed by authorities, and guidelines developed by any other institution or (group of) individuals. Several national and regional standards are published and available, such as the so-called standards by the International Association for K-12 Online Learning (2011). This name is misleading as the standards are merely a second version of a national US standard originally developed and published by a few American authors (and not by an international association or large group of authors).

The first international standard that is relevant for online courses was published by the Institute of Electrical and Electronics Engineers (IEEE, 2003) as IEEE Std 1484.1. It specifies all components of a Learning Technology Systems Architecture (LTSA) and their relations in a completely technology-independent description (see Fig. 2 below).

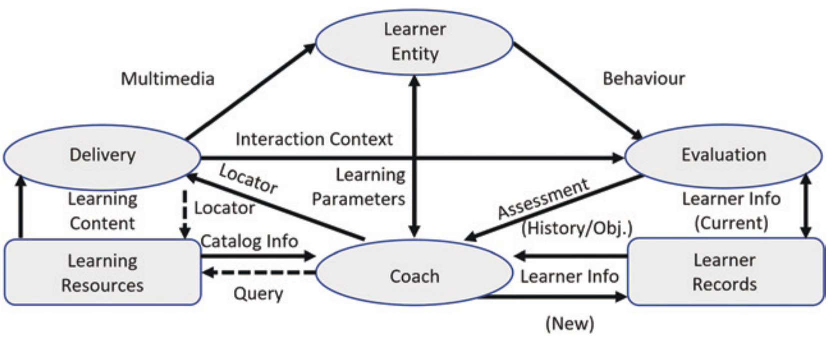

Fig. 2 IEEE 1484.1: LTSA system components (IEEE, 2003)

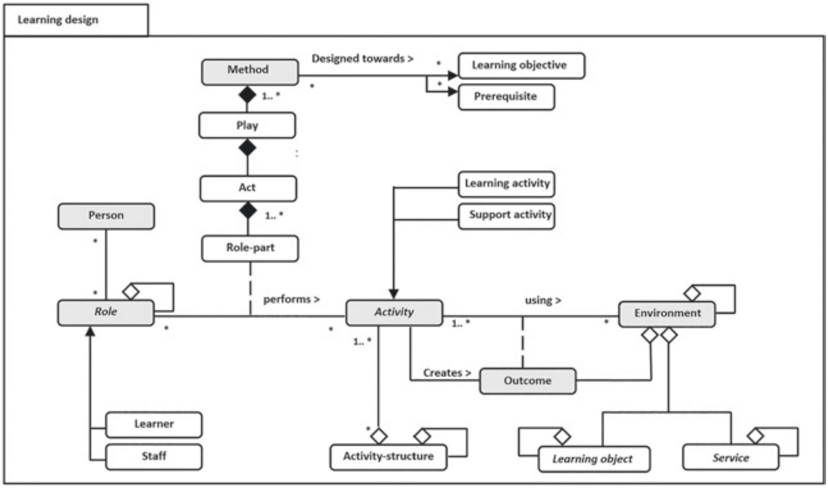

Fig. 3 IMS learning design (IMS, 2003)

It is remarkable how useful and adequate this norm still is, considering its age (18 years old now) and the technological developments that have occurred since its creation.

In the same year (2003), another international standard, IMS Learning Design (LD), was published by IMS Global Learning Consortium, Inc. (IMS), based on the Educational Modelling Language (EML) (see Fig. 3 above).

An extension of IMS LD was developed from 2003 to 2004 and published as publicly available specification 1032-2 by the German Institute for Standardization. It enhanced the IMS LD specification by three components, namely, context, experience, and metadata.

However, none of these standards are internationally approved or broadly implemented as a norm. The single exception was and still is the unique international quality norm ISO/IEC 40180 (2017), developed and approved by all national delegations from the International Standardization Organisation (ISO) and the International Electrotechnical Commission (IEC). ISO/IEC 40180 is a regular revision of the former standard ISO/IEC 19796-1 (2005) that was published as the first e-learning norm by ISO and IEC. It was developed by the international standardisation committee SC36 under the ISO and IEC, managed by the elected SC36 Convenor Christian M. Stracke, and approved by all participating national delegations from approximately 60 countries in a consensus. ISO/

<table>
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Sub-aspects</td><td colspan="3"></td></tr>
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<tr><td colspan="2">Metrics/Criteria</td><td colspan="3"></td></tr>
<tr><td colspan="2">Standards</td><td colspan="3"></td></tr>
<tr><td colspan="2">Annotation/Example</td><td colspan="3"></td></tr>
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Fig. 4 ISO/IEC 40180: QRF Descriptive Model (ISO, 2017)

IEC 40180 defines the QRF for e-learning that contains two models: the QRF Descriptive Model (as a master template, presented in Fig. 4) and the QRF Quality Model that describes all relevant dimensions and processes relevant for online learning and courses (presented in Fig. 5). As it is based on the QRF of ISO/IEC 40180, MOOQ chose to use the same abbreviation, QRF, for its specific QRF for MOOCs (see above).

The QRF Descriptive Model provides a template for defining and describing selected processes relevant in a given situation and for a specific task, such as designing an online course. The QRF Quality Model contains all potential processes that are relevant and must be defined in technology-enhanced education, namely, in digital learning and online courses. By virtue of this complete picture of all potential dimensions and processes, the structure of ISO/IEC 40180 with its 7 dimensions and 38 processes is used in the following framework as the basis for categorising online courses.

In Table 2, we compare the different dimensions and categorisations of online courses used in the standards and the norm ISO/IEC 40180 plus the QRF introduced above to develop the TOC framework below.

4 TOC Framework

It is evident at first glance that there is a major discrepancy between the international norm ISO/IEC 40180 and QRF, on one hand and the practical implementations in online platforms on the other. ISO/IEC 40180 and QRF address all

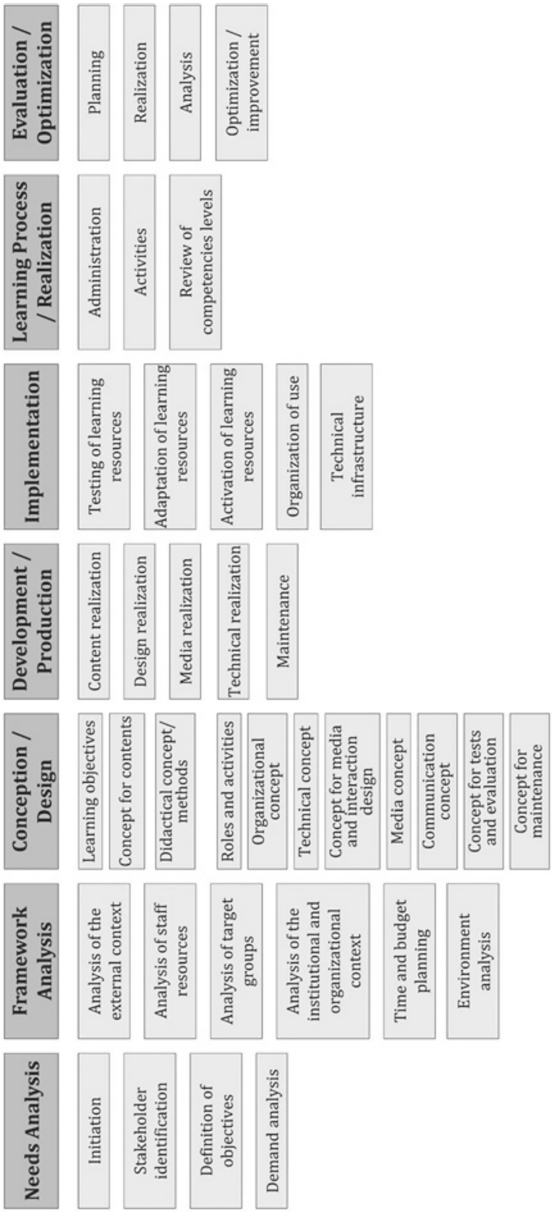

Fig. 5 ISO/IEC 40180: QRF Quality Model (ISO, 2017)

Table 2 Categories of Online Courses Differentiated in Standards and Norms

	ISO/IEC 40180	IMS LD	IEEE LTSA	QRF
Objectives	Definition of objectives Learning objectives	Learning objective		Definition of objectives Learning objectives
Target group	Demand analysis Analysis of target groups	Person Prerequisite	Learner entity	Needs and demand analysis
Pedagogies	Didactical concept/methods Roles and activities Organisational concept Communication concept Organisation of use Activities	Method Play Act Role-part Role Activity Activity structure Learning activity Support activity	Delivery Coach	Organisational concept and roles Didactical concept and methods Concept for learning activities Communication concept Interaction concept Feedback concept Organisation of use Learning activities and related support
Content	Concept for contents Media concept Content realisation Media realisation Testing of learning resources Adaptation of learning resources	Learning object Service	Learning resources	Concept for contents Media design Content realisation Media realisation
Design	Concept for media and interaction design Design realisation			Design realisation
Technologies	Technical concept Concept for maintenance Technical realisation Maintenance Activation of learning resources Technical infrastructure	Environment		Technical concept Technical realisation Testing and activation

(continued)

Table 2 (continued)

	ISO/IEC 40180	IMS LD	IEEE LTSA	QRF
Assessment	Concept for tests and evaluation Review of competencies levels	Outcome	Evaluation Learner records	Concept for tests and assessment Review of competence levels
Context	Initiation Stakeholder identification Analysis of external context Analysis of staff resources Analysis of institutional and organisational context Time and budget planning Environment analysis Administration			Initiation Stakeholder identification Analysis of the external context Analysis of the organisational context Time, resources, and budget planning Administration
Evaluation	Planning Realisation Analysis Optimisation/improvement			Evaluation planning Evaluation realisation Evaluation review Improvements and optimisation

important dimensions and processes with a strong emphasis on pedagogical categories; this is also supported by the scientific literature and studies. However, online platforms largely neglect these aspects and concentrate mainly on formal aspects and categories directly related to content. The standards for online learning and courses take a middle position due to their specific orientations (IEEE 1484.1 on information systems and IMS LD on pedagogical views). Consequently, we propose a future framework for the typologies of online courses that is more concise than ISO/IEC 40180 and QRF but that still addresses all their details. This can be achieved by a reduced and limited set of dimensions enhanced by detailed (sub-)categories that are representative for online courses and that can be used and adapted for their design, quality, and evaluation. Table 3 presents our proposal for a Typologies of Online Courses (TOC) framework derived from our analysis results, as discussed above.

Table 3 Dimensions of a Typologies of Online Courses (TOC) Framework

Context	The given context is crucial for the design of an online course. Specific conditions and the given limitations such as available resources have to be identified and considered. Therefore, the design should start with a needs analysis that also reflects the requirements and demands of all the stakeholders involved
Objectives	This dimension covers the organisational objectives related to the expected impact as well as learning objectives associated with the planned learning outcomes
Pedagogy	The dimension pedagogy can be considered to be most important for overall success and requires close attention and addressing several aspects. In online courses, there are several unique opportunities that need to be exploited such as community building, collaborative learning, and automatic self-assessment
Content	Content covers the resources and media that are combined and mixed in the online course
Interaction	Interactions in online courses are enriched by a fourth mode—the interactions among different groups of learners, as explained above. Online learners as well as online designers highly value this feature although the learners and designers have diverse expectations
Technologies	Technologies play a special role in online courses as they have to work, and learners (as well as designers and facilitators) need related digital competences
Support	Support in online courses is crucial for introducing beginners to online learning, giving orientation, and providing feedback
Assessment	The assessment consists of measurement of the learning progress and outcomes achieved by the learners as well as the evaluation of the online course for future improvements

It is important to note that there is no specific sequence of the dimensions. Instead, there are generally iterative definitions and refinements of all dimensions in cycles. This is not finalised during the design but continues during the implementation, realisation, and (formative and summative) evaluation as stated and required in ISO/IEC 40180 and QRF. Our aim is to enhance our framework proposal with detailed categories for the design, quality, and evaluation of online courses. Furthermore, a task for future research will be to add appropriate analysis methodologies and validate them through mixed methods research involving learners, designers, and providers of online courses.

5 Conclusion: (Open) Online Courses and their Contributions to DLE

It has become evident that online learning and courses will play a more important role in the future (Qayyum & Zawacki-Richter, 2019), independent of the continuation of the COVID-19 pandemic. Teachers, students, and their families have been forced into their first experiences with online learning and courses in formal education and some of these experiences have been quite positive. Therefore, we believe that this sudden introduction of online learning and courses or at least their beneficial aspects that teachers, students, and their schools and universities have discovered will stay. Consequently, an in-depth research on the dimensions, conditions, and effects of online learning and courses is required to identify their prerequisites, factors, and impact.

In this chapter, we have presented and discussed the results from our literature review and analysis of standards and current practices as well as online platforms for online learning and courses. We state that there is an great difference between scientific publications and studies, on one hand and current practices and online platforms on the other. By comparing the identified dimensions and categories of online courses, we can derive and propose a TOC framework consisting of eight dimensions: Context, objectives, pedagogy, content, interaction, technologies, support, and assessment.

As an outline for future research and for embedding this chapter into the broader context of this handbook, we will briefly highlight how (open) online courses can support and strengthen digital education and DLE, particularly in the movement towards open education (Kerres & Heinen, 2015; Koseoglu & Bozkurt, 2018). We selected two types of online courses that are currently most prominent in online learning and education: OER and MOOCs.

5.1 Open Educational Resources (OER)

The OER movement is older than MOOCs (Stracke et al., 2019); it is connected to the evolution of the movement towards Open Learning and Open Education (the favoured term has changed over time) that started some thousands of years ago in the philosophies of Confucius, Socrates, and Plato (Nyberg, 1975; Stracke, 2019). The concept of OER is used in two ways: narrowly, for freely and openly accessible learning materials with an open license, and broadly, for a grassroot movement towards designing, sharing, and re-using open education for all (for diverse definitions, see D'Antoni (2009), Downes (1996, 2007), McAndrew (2010), and Stracke et al. (2019)). The main institutional driver was (and still is) UNESCO (2002), which introduced the term OER in 2002; followed by many OER reports, declarations, and guidelines such as the Cape Town Open Education Declaration (2007), the Dakar Declaration on OER (2009), and the Guidelines on Open Educational Resources in Higher Education (2011) (Atkins et al., 2007; Stracke et al., 2019).

The two World OER congresses organised by UNESCO (2012 in Paris and 2017 in Ljubljana) were milestones for the global OER movement, leading to the global OER Recommendation (UNESCO, 2019), approved by all 194 member states. The recommendation's unique characteristic is the binding requirement for all member countries to deliver annual national reports about their OER status and progress. Research on OER has increased and the latest findings of a comparison of 25 OER projects (Otto, 2019) demonstrate the diverse adoptions and diffusions of OER in education. A survey among designers of online courses from four selected European countries reveals that OER are most used (35%) after PowerPoint slides (85%) and videos (36%) (Meletiou-Mavrotheris et al., 2021), which demonstrates the potential of OER that still needs to be fully exploited.

5.2 Massive Open Online Courses (MOOCs)

Open online courses existed before MOOCs; these courses started with email-based classes in the 1990s (Abdolrasulnia et al., 2004; Hodges, 2008; Smith et al., 1999), followed by self-paced online courses in the late 1990s and early 2000s (Wiley & Gurrell, 2009). MOOCs were born in 2008 with the online course "Connectivism and Connective Knowledge" (CCK08), which later became known as MOOC, a term coined by Dave Cormier (Bozkurt et al., 2018). The debate over whether MOOCs are OER has been clarified and answered by Stracke et al. (2019) in their detailed historical overview and discussion, which pointing out that it depended on the chosen definitions and perspectives.

Since the beginning, the number of MOOCs has been constantly growing (Daniel, 2012; Gaskell & Mills, 2014; Pappano, 2012), and online designers and researchers have discussed and analysed the quality of MOOCs and their educational impact and achievements (Liyanagunawardena et al., 2013; Stracke, 2019; Stracke & Trisolini, 2021; Veletsianos & Shepherdson, 2016; Zawacki-Richter et al., 2018). Consequently, different types of MOOCs have been designed with specific learning objectives and pedagogical approaches (Davidson, 2013; Stracke, 2017). Today, the numbers of offered and registered MOOCs (16,300 as of 2020), participating learners (180 million), and providers (950+) are continuously increasing, as reported by the MOOC platform and aggregator website Class Central; especially during the COVID-19 pandemic and the resulting lockdowns, the demand and the registrations for MOOCs have grown strongly (Shah, 2020).

5.3 Contributions of OER and MOOCs to Online Courses and DLE

Two main questions remain to be briefly discussed. First, how can OER and MOOCs improve online courses and their design, quality, and evaluation? Second, how can OER and MOOCs strengthen DLE?

The answer to the first question appears to be evident: OER and MOOCs offer open and free concepts, materials, and methods that can be re-used and adapted by online designers using free formats. Moreover, they benefit from open licenses, for example, for situational, cultural, or language modifications. Furthermore, online learners can openly and freely register for and take OER and MOOCs. This open approach benefits both designers and learners, allowing for variety, better comparability, and transparent evaluation, leading ideally to improved design and quality of online courses. Designers can benefit from development experiences (and do not have to start from scratch), while learners can benefit from easier comparisons. However, this direct consequence still needs to be proven by future research on the impact of (open) online courses.

The answer to the second question depends on how OER and MOOCs are designed and used by designers as well as learners. Both designers and learners have to embrace the opportunities of (open) online courses, namely, their potential for equity and collaborative development and learning. In the best approach, through their learning objectives, design, and tasks, OER and MOOCs demand collaborative and networked learning that would directly facilitate DLE. Here, we need an increased understanding about the driving forces and success factors behind DLE in complex and longitudinal research studies. We hope that the coming years can provide such experiences and research results to continuously improve online courses and DLE and the understanding of both.

In summary, digital education and online courses have started to dramatically change learning (especially formal learning), which is an accidental consequence of the COVID-19 pandemic. This chapter provides the first insights into their dimensions and introduces the TOC framework. OER and MOOCs are strong candidates for the broad implementation of digital education and particularly DLE as they require and support equity and collaborative learning ecosystems—MOOCs aiming to open education to all.

For future research, it would be beneficial to conduct a systematic literature review of the typologies of online courses with a special focus on the characteristics of open online courses and their potential contributions to improving online learning for all. We need additional insights into successful, effective, and efficient online courses and digital learning in general. Further, we believe that open learning and education can strongly contribute to such digital learning and facilitate (open and online) education for all as one of the sustainable development goals (United Nations, 2015).

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Open Textbooks in Higher Education Teaching

Rebecca Pitt

Abstract

Open Educational Resources (OER) are learning materials available under licensing terms that enable their use, sharing, reproduction, and often adaptation without needing further permission from the author or copyright holder. Whilst OER are available in many different formats, open textbooks—complete course books available on open licenses—have been particularly successful in facilitating widespread use of OER in some regions, such as North America. This chapter surveys the current extent and future potential use of open textbooks in Higher Education (HE), examining how open textbooks are used to address challenges in HE and describing opportunities for connecting and enabling institutional and extra-institutional communities through the use of open textbooks. While open textbook ecosystems are well developed in some countries, elsewhere the role of open textbooks remains emergent. This chapter examines the nuances in open textbook use and what lessons can be learnt from both more mature ecosystems and those where open textbook use remains limited.

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1 Introduction

The COVID-19 pandemic has sharply highlighted and deepened existing inequalities in education (e.g., Adams, 2021; Bozkurt et al., 2020; Czerniewicz, 2021; Saavedra, 2021; Xiao, 2021). In Higher Education (HE), the move to teaching at a distance and the challenges of rapidly moving to online teaching and learning have both revealed previously ignored or hidden inequalities whilst simultaneously demanding that these are addressed. With regard to learning materials, library access has often been restricted and, consequently, supporting students with relevant books and materials online has become even more critical (França, 2021). As Czerniewicz (2021) observes in her assessment of the impact of the COVID-19 pandemic on HE, "now that the impacts of inequality are clear and visible, they must never again be rendered unseen." One consequence of the pandemic, and the centring of what may have been "unseen" by some but was a lived experience for many, is that discussions on pedagogical approaches which centre equity, care, and social justice have come to the fore (e.g., Bozkurt et al., 2020; Xiao, 2021).

It is one of these inequalities, access to textbooks, and one solution, open textbooks, which are the focus of this chapter. The idea of open textbook initiatives as ecosystems is not new (e.g., Baraniuk et al., 2017), and both emergent and mature examples of these have an important role in providing examples of who and what is involved in sustaining the production and use of OER such as open textbooks. Moreover, as will be seen, open textbook ecosystems are by necessity and design 'open' in different ways, drawing on wider community experiences and more established initiatives or technologies, whilst acknowledging these as a contrast to commercial publishing models.

This chapter surveys the development and focus on open textbooks in some regions of the world, examining the factors that have led to or hindered their use. What factors have enabled well developed open textbook ecosystems to emerge whilst elsewhere their role is emergent? What lessons can be learnt from different contexts? Moreover, how can open textbooks be used to address the current challenges in HE whilst also offering the potential to connect and enable communities both within and outside HE institutions in their development and use?

2 OER Ecosystems

Understanding who and what supports and sustains the use of OER at certain points and the possibilities for their future development are important in shaping strategy and focus for organisations, government bodies, and institutions.

In their analysis *The Open Educational Resources Ecosystem…* The Boston Consulting Group (2013) identified, categorised, and analysed levels of awareness, provision, and different uses of OER and open pedagogies and institutional and legislative support for the use of OER. Through this analysis, key areas enabling “mainstream adoption” were identified. The analysis and recommendations were reflective specifically of the US context and particularly reflected the emergent importance of open textbooks for potentially enabling widespread adoption of OER.

Five years later, and reflective of the accelerated development and adoption of OER (in particular open textbooks) within the US context, Huttner et al. (2018) published their report *Seeking a sustainable OER ecosystem*. This analysis is reflective of the maturity of the ecosystem; the growing availability and range of curriculum-aligned OER specifically developed and produced for the USA context, support for use of OER, as well as recent governmental support and funding for initiatives (Huttner et al., 2018; SPARC, n. d.b). The focus of this analysis is how to ensure longevity by identifying and collectively addressing challenges which have emerged, including the financial sustainability of OER initiatives.

Huttner et al. (2018) present a model which draws on, and combines, two different approaches to OER ecosystem models to date, those which are “values-driven” and “incentive-driven” (pp. 2 & 11). Aligning those involved in sustaining “the essential processes of a sustainable OER commons” at different points and alongside key activities shows that whilst sustainability may not involve a radical shift from existing structures and requirements (e.g., “use tech and data to increase engagement and track results”), OER ecosystems should reflect and integrate openness, for example through the use of open pedagogies (Huttner et al., 2018, pp. 8 & 17). “Five core challenges” (resourcing, institutional support, adoption support, educator support, and open pedagogy and the dominance of North American/English language OER) are also discussed and different possible responses to them explored (Huttner et al., 2018, pp. 2 & 13–18). Some potential compromises (such as “accepting the inclusion of organizations driven by profit or other factors”) are also highlighted as possibilities as the OER ecosystem continues to develop (Huttner et al., 2018, p. 3).

Both The Boston Consulting Group (2013) and Huttner et al. (2018) analyses are focused on the USA context, and therefore American OER ecosystems, specifically. Within this context, there is a focus on open textbooks as the driver for OER adoption and specific contextual considerations and challenges. However, whilst OER may initially be created for specific audiences and educational contexts, OER are also shared publicly, with no barrier to access and can, therefore, (putting aside issues of findability/visibility) potentially be used more widely than just by their intended audience(s). Consequently, there are also critical wider issues that should be reflected and acknowledged by OER ecosystems. Huttner et al. (2018) acknowledge this in their fifth "core challenge" and their discussion of the dominance of North American/English language OER (pp. 17–18).

Developing OER ecosystems that reflect current practice while also potentially offering alternatives to, or reimagining and extending, existing educational practices is by necessity nuanced and contextually specific. Whilst more mature OER ecosystems can provide potential inspiration, for example by suggesting collaboration with a range of education providers (see Huttner et al., 2018, p. 18), existing successful approaches should not be prescriptively applied across varied contexts (see also Baraniuk et al., 2017). Thus, in tandem with the possibilities that openness presents, there is the possibility of a fusion of multiple OER ecosystems: a criss-cross of organisations, individuals, and systems which have the potential to support various ecosystems with their platforms, tools, and resources, depending on their relevance to specific contexts and requirements.

3 Why Open Textbooks?

Open textbooks are a type of open educational resource (OER). More specifically, open textbooks are complete resources, presented in textbook format and either created from scratch or by partially or wholly curating existing OER. They are created in different ways, authored by individual educators, groups of experts, or even by students as part of their course assessment. Open textbooks are 'open' as they utilise open licences (such as Creative Commons) to enable users to reuse and often adapt the content without needing to seek further permissions from the copyright holder. 'Open' textbooks are typically made available digitally at no cost to the user.

Farrow et al. (2020) describe two main drivers for the popularity of open textbooks (p. 230). The first is the high cost of textbooks, which has been a long-standing concern and acted as a focus for advocacy, particularly in North America. Whilst textbook costs have outpaced inflation since the late 1970s, they have also accelerated in recent years. SPARC, for example, reports that "College textbook prices rose 82% between 2003 and 2013, approximately *triple the rate of inflation* in overall consumer prices (CPI) during the same time (27%)" (SPARC, n. d.a). Where available, complete resources, such as open textbooks, offer an immediate and accessible solution to expensive hardcopy or e-book materials. Whilst textbook costs are a long-standing issue in a number of countries, as will be seen later in this chapter, the sharp increase in the cost of educational resources during the COVID-19 pandemic has further compounded this issue for students and institutions. The second driver for open textbook use is the pedagogical possibilities that are granted through the open licence itself. These permissions enable the adaptation of resources to better suit learner and educator needs.

Addressing the issue of textbook costs depends on a number of factors, and the success of open textbooks partly depends on both an awareness of and response to the changing strategies used by publishers as they attempt to reconfigure the publishing playing field and preserve market share. A recent analysis of the publishing industry (Aspesi et al., 2019) outlines a range of publisher strategies and interventions intended to both diversify and maintain control of educational textbook markets in response to reduced spending by libraries and students. Some of these strategies, for example analytics, ensure that textbook publishers exert far greater control over institutional decisions and infrastructure than previously (Aspesi et al., 2019).

A clear picture of OER awareness and use over a sustained period is available in a limited number of regions, tending to those where more mature open textbook ecosystems are present. Research by Seaman and Seaman (2021), for example, has documented USA educator awareness of OER over a number of years, whilst the periodic Florida Virtual Campus (n. d.) survey of students charts textbook perceptions and use. In their latest report, Seaman and Seaman (2021) note the continual increase in US educator awareness of OER over the 2014–2020 period. For example, during 2019–2020, 58% of educators surveyed said they had at least some familiarity with OER in comparison with 34% in the 2014–5 period (Seaman & Seaman, 2021, p. 31). As above, this is reflective of increased advocacy for open textbooks, changes in federal and state level policies, increased availability of ready-to-use open textbook material that is curriculum-aligned over this period, and, as Seaman and Seaman report, institutional support (Seaman & Seaman, 2021, p. 42). Moreover, whilst there have been concerted efforts to foreground how open resources, such as textbooks, meet expected standards (through, for example, peer review of open material in repositories or clearer explanations of the process by which open textbooks are created), such long-standing concerns regarding quality (e.g., Hilton, 2020) appear to remain an issue for educators who have not yet used OER (Seaman & Seaman, 2021).

Whilst in the USA, there is year-on-year improvement in the number of educators who are aware of OER, in the UK awareness of OER remains low. In their 2018 survey of UK HE educators, The UK Open Textbook project revealed lack of awareness of OER and open textbooks, but enthusiasm for their potential use (see Farrow et al., 2020; Pitt et al., 2019, 2020). However, although in general awareness of OER is low and there is a lack of national OER policy, a number of UK universities have OER policies and initiatives such as Open Scotland advocate for national policy and sector wide change (Open Scotland, n. d.). There is great potential; as seen in the case of open access (OA) publishing in the UK, changes to national, funder and university policy (see e.g. UK Research and Innovation (UKRI), 2021), impact on educator awareness and practice.

As open textbooks have established themselves over the past decade, there has also been a concerted effort to increase the amount of research on their impact. In a synthesis of current research into the impact of OER, Hilton (2020) notes that "results across these studies suggest students achieve the same or better learning outcomes when using OER while saving significant amounts of money" as well as a wide range of other positive impacts.

4 Open Textbook Ecosystems

As noted earlier, publishers have continued to diversify their offerings (see Aspesi et al., 2019). Seaman and Seaman's (2021) report on the USA context summarises a number of changes that occurred around the 2015/6 time and transformed the terrain of textbook publishing. These include increased educator awareness of the impact of learning material cost on students, proprietary publisher responses to this growing awareness, a shift in marketing strategy and offering which requires more centralised and less educator decision making around resources, and educator willingness to use more digital resources and the subsequent rise in provision of these (Seaman & Seaman, 2021, p. 9). Some of these changes, such as an increase in digital resources associated with a textbook, have resulted in changed educator expectations and, consequently, a need for open textbook publishers to formalise and increase the development of ancillary resources provided.

By developing comparable offerings to those available via commercial publishers, there is a move towards an OER ecosystem that offers the 'complete package' and removes barriers to the use of open textbooks (Baraniuk, et al., 2017, p. 222). Baraniuk et al. (2017) highlight the importance of understanding and responding to commercial publishing strategies in their discussion of how OpenStax, based at Rice University and publishers of over 60 open textbooks aimed at US HE audiences, developed their "successful, sustainable OER model." This involved identifying and responding to two challenges commercial publishers were facing: "digital rights management (DRM) restrictions and the lack of collaboration among providers in the market" (Baraniuk et al., 2017, p. 222).

The result is a strategically developed “distributed ecosystem model” that contrasts with the “one size fits all” closed approach of publishers (Baraniuk et al., 2017, p. 223). OpenStax partner with a number of non-profit and for-profit providers who, as OpenStax Allies, provide a variety free and costed add-ons to open textbooks, for example labs, simulations, and homework systems. Consequently, “the ecosystem model spurs choice by allowing the educator to decide which resources best align to their curricular goals.” (Baraniuk et al., 2017, p. 224). In addition, other resources, such as PowerPoint slides and materials created by other educators, are also available to support textbook use. OpenStax also offer educators a paid platform for a selected number of textbooks that enables customisation and presentation of textbooks into complete courses.

As an open textbook ecosystem develops and matures, strategies for engaging different stakeholders require consideration. The OpenStax website states they offer “free and flexible textbooks and resources” (OpenStax, n. d.b); a clear, meaningful offer, regardless of awareness of OER, and which focuses on pertinent issues rather than on ‘open’ in and of itself (see Baraniuk et al., 2017). South African based open textbook providers Siyavula took a similar approach (Lambert, 2019). This strategy is particularly important given varying levels of OER awareness in different regions.

In instances where open textbooks are curriculum aligned and therefore complete resources, their use does not necessarily require any adaptation or localisation and therefore awareness of open licensing. As Jhangiani (2017) notes, focusing on cost, whilst initially “appropriate, even pragmatic,” requires recognition that this message is not only context and stakeholder specific, but could also potentially hinder adopter engagement with the full possibilities that OER offer (p. 142). Whilst subsequent adaptation and localisation of material often occurs once the resource has been used initially (e.g., Pitt, 2015), how to both initially and continually engage appropriately with different users and stakeholders as they use and engage with OER and open textbooks in different ways is critical.

The OpenStax ecosystem has emerged and been refined since 2012, from the first textbooks and educator sharing of resources to support the use of specific textbooks (see Pitt, 2014) to today’s multi-faceted and layered offering building on the core, free textbooks, and featuring revenue streams for sustainability and cost-effective packages of resources and technologies to better compete with proprietary offerings (Baraniuk et al., 2017). The OpenStax strategy has been highly successful, with the impact and use of these resources more widespread than US HE; whilst OpenStax textbooks are now used by 60% of all USA colleges and universities, they are also known to be use in over 120 countries (OpenStax, n. d.a).

Another open textbook ecosystem that has emerged and developed iteratively over a sustained period is The Open Education Network (formerly The Open Textbook Network). A membership organisation, the network has developed to include extensive support and networking for educators and institutions who are developing, publishing, and sharing open textbooks. The network also hosts an extensive curation of, at the time of writing, over 900 open textbooks (Open Textbook Library, n. d.). The curation of materials, which can be easily searched and assessed by educators, addresses long-standing perceived barriers to OER uptake including quality and visibility of resources.

These mature open textbook ecosystem examples are focused primarily on the national level, providing different types of support for the use of open textbooks. In the first instance, support is via an ecosystem of USA curriculum-aligned resources and technologies (e.g., Baraniuk et al., 2017) whilst in the second, support is through networks of educators and programmes to further the implementation, adaptation, and development of resources (Open Textbook Library, n. d.). Both provide different, successful approaches to addressing identified barriers to the use of OER and open textbooks (Pitt et al., 2019; Farrow et al., 2020).

Elsewhere, similarly mature ecosystems have emerged from different funding and support structures. In their discussion of Canadian OER initiatives, McGreal, Anderson and Conrad (2015) note that education is completely devolved to each province. Consequently, open textbook and OER initiatives are funded at, and focus on, the province level with the Canada OER Group serving as a connecting point for work across the country (BCcampus, n. d.). Canadian open textbook ecosystems also originate and are aimed to primarily serve students within a specific province. In British Columbia, BCcampus has seen a series of province-funded grants from 2012 onwards to support the development of open textbooks where there is "skills gaps or projected skills gaps" or for courses with large numbers of students and support their further localisation at colleges and universities across the region (Burgess, 2017, p. 228).

As Burgess (2017) describes, developing an ecosystem with educators, students, and the wider community, alongside experienced open textbook advocates and publishers early in the project enabled it to flourish and become established and, over time, engendered widespread support for open resources and practices. Directly addressing concerns, such as lack of ancillary resources for open textbooks, was also critical and the development of these through co-creation also brought educators together from across the province. Finally, it is of note that Burgess also describes an "ecosystem of technologies" that BCcampus drew on to help support textbook development and implementation, providing features to support ease of use (Burgess, 2017). Again, large scale textbook initiatives involve a close understanding of barriers to open textbook use and draw on the wider community and technologies to support their development.

Elsewhere in Canada, eCampusOntario support open textbook use amongst educators and institutions across the province. Their *Open Library* enables educators in the province to easily find high enrolment discipline materials and customise these. Educator reviews of materials and reporting material adoption are also encouraged. Training and materials to support and promote OER use are also available (Open Library, n. d.).

5 Emergent Open Textbook Ecosystems

Mature and/or large open textbook ecosystems display a number of similar characteristics. They are open and interconnected, drawing on national and/or international community expertise and resources to develop material and connect with partners or providers who can support additional technologies. They are also aware of, and responsive to, the potential barriers to, and expectations of educators and students regarding open textbook use. An awareness of the wider challenges faced by the publishing industry and how different open textbook models can address these is also key to developing effective strategies for open textbook development, curation, and support.

The applicability or success of open textbooks in different contexts in HE depends on a number of factors. When the pilot UK Open Textbook project tested the applicability of two mature models of USA open textbook adoption (OpenStax and the Open Education Network) within the UK HE context, it was clear that despite lack of awareness of OER, there was a high level of interest in this type of resource (Farrow et al., 2020; Pitt et al., 2019, 2020). Whilst further research is needed, "textbook cost is an increasing area of concern" within wider discussions on the high cost of UK HE (Farrow et al., 2020; Pitt et al., 2019, p. 5, 2020). However, unlike North America, at UK universities there is less focus on one specific textbook for a course, which means open textbooks are likely to be utilised differently within this context (Farrow et al., 2020; Pitt et al., 2019).

A closer look at different open textbook initiatives around the world highlights some of the differences in both context and requirements for instigating initiatives that curate and create open textbooks. Open Textbooks for Hong Kong, for example, created and curated open textbooks for all education levels (Open Textbooks for Hong Kong, n. d.) Describing the process to set up the initiative, it is notable that textbooks were at that point primarily hardcopy, with a reluctance of publishers to move to online provision (Cheung, 2016). This aligns with the lack of a platform to support the sharing and use of open content (Cheung, 2016), revealing specific local challenges to be addressed.

In Poland, governmental support for a nationwide open textbook initiative has focused on early years and compulsory education, where whether materials are up-to-date and their cost are a concern (Hagemann & Hugyecz, 2016). As in Poland and elsewhere (e.g., Pitt et al., 2019; Farrow et al., 2020), the cost of textbooks is not a problem unique to HE. Curriculum-aligned and accessible, there is a range of materials currently available (Zintegrowana Platforma Edukacyjna, n. d.). Alongside this national initiative, specific publishers such as OpenStax have focused attention on HE. Working with Katalyst Education, OpenStax have published 4 textbooks in Polish alongside their English language offerings since 2015 (OpenStax Polska, n. d.). OpenStax textbooks are currently in known use in 134 universities across Poland (OpenStax Polska, n. d.), over one third of the 349 HEIs in the country (European Commission, 2022). Understanding where existing textbooks could be localised and translated for use is critical; a sub-section of Polish universities have courses that could utilise a remixed version of the *University Physics* textbook, for example (Ruth, 2017). This strategy could potentially be replicated in other contexts, for example the UK, if there was sufficient institutional coordination and collaboration. Elsewhere, in South Africa, support at government level took a different form and facilitated the distribution of Siyavula mathematics and science open textbooks across the country to 2.5 million primary school children (McGivern & SF Team, 2017; Lambert, 2019).

Whilst the issues of access and cost are central to open textbook uptake, their use is often critical for disadvantaged and underserved populations who face multiple barriers to participating fully in their studies. As Seaman and Seaman note, within the US context, “minority-serving faculty have a clear lead in the rate of OER adoption” (Seaman & Seaman, 2021, p. 38). A number of projects now centre on social justice in open textbook advocacy and use. For example, Digital Open Textbooks for Development (DOT4D) at the University of Cape Town, South Africa evaluates and supports open textbook development at both the institutional and national level (DOT4D, n. d.). Central to the project is an acknowledgement of the legacy of apartheid and colonialism and dominance of Global North narratives and resources within education and underlying the inequalities that persist today and which underpin the lack of access and cost issues in HE (e.g., Cox et al., 2020). Involving students in the creation of textbooks and developing models of textbook production which reflect the experiences of the project’s 11 open textbook creators are also in development (Cox et al., 2021). Elsewhere, in Australia, the Australian Open Textbooks as Social Justice project

(2020–2021) builds on open textbook research done by projects such as UK Open Textbooks to explore and focus on social justice, particularly with regard to marginalised and indigenous learners (Australian Open Textbooks as Social Justice, n. d.)

6 The Future of Open Textbooks

Textbook publisher responses to the pandemic have resulted in an increase in e-book costs, as many students across the world are studying remotely rather than in face-to-face classes. The impact of this on institutions, educators, and students is emergent; however, it is clear that, in some instances, this has accelerated demand for open textbooks and institutional responses to this issue. The issue of textbooks has become "seen".

In the UK, over the 2010–2019 period, it was estimated that £1 billion was spent by universities on resources from the largest 10 publishers (Grove, 2020). However, during 2020, lack of access to physical textbooks and the corresponding rise in demand for e-books, coupled with a rapid rise in their cost, forced UK institutions to engage intensively with the issue of textbook costs (Fazackerley, 2021; França, 2021). Whilst free access was granted to e-books by publishers for a limited time, subsequently shifting from printed to e-books has highlighted a number of issues; as França (2021) explains "Whilst the issues around e-textbook access are complex, the overriding barrier to making these titles available to our students has been one of cost…" (p. 3). Similarly, within the US context, a US Public Interest Research Group (PIRG) survey of 5000 District of Columbia students in September 2020 revealed that the impact of the pandemic on student employment had, in turn, impacted on students' ability to purchase online course materials, including access codes which allow not only access to textbook material but to assignments and other course materials (Nagle & Vitez, 2021; Shalabi, 2021).

In the UK, this has crystalised in a range of activities during the 2020–21 period. The pandemic has accelerated some universities, such as University College London (UCL), to publish their own open textbooks using their open press; planning to develop a "membership coalition" to benefit UK HE more generally in future (Anderson et al., 2021). As reported in March 2021, "…UCL had to find £3 million extra and recurrent funding in 2020 (because of the pandemic) to support students whilst libraries were closed" (Anderson et al., 2021). Similarly, The University of Edinburgh's collaborative *Open eTextbooks for Access* *to Music Education* project remixed existing MOOC content to produce a music theory open textbook (Campbell, 2021). Whilst responding to existing sectoral challenges, the increase in e-textbook costs during the pandemic is cited as giving even greater importance to this pilot project (Campbell, 2021). At a national level, the librarian-led UK #ebookSOS project has acted as a focal point for increased high cost of e-books during the pandemic and its impact on the sector, and has received support from thousands of higher education professionals (Campaign to Investigate the Academic eBook Market, n. d.).

Whilst prior to the pandemic a number of factors had led to accelerated use and focus on open textbooks in some regions of the world, such as North America, as can be seen within the UK context, the pandemic has led to coordination and advocacy around e-book costs and highlighted previously recognised but largely "unseen" issues such as the cost of textbooks. As Anderson et al. (2021) note, this is a pivotal moment: "…the current situation with e-textbooks feels like the situation with OA to research materials 15 years ago." As noted earlier, familiarity with open access (OA) in UK HE is high compared with that of OER and open textbooks, as a result of changes in policy. The work of the UK Open Textbook project showed "potentially fertile ground" for open textbooks (Pitt et al., 2019, p. 2, 2020; Farrow et al., 2020) pre-pandemic. As shown in the examples of emerging UK open textbook ecosystems described above, the pandemic has led to a renewed focus on the possibilities of open textbooks.

Within the USA context, Seaman and Seaman (2021) report that whilst there was an increase in OER awareness in 2020 during the pandemic, this did not translate to an increase in use of OER, in contrast to previous years (Seaman & Seaman, 2021). Whilst use of OER as "supplementary" continued to increase for foundation level courses, it reduced slightly during the latest survey for all courses taught (Seaman & Seaman, 2021). The reasons for this are currently unknown; however, it is arguably the case that many educators were focused on supporting their students and colleagues and shifting their teaching online over this period, rather than reviewing or reworking open materials for use in the classroom (see Seaman & Seaman, 2021). It is of note, however, that OpenStax report interest in their materials during the pandemic having accelerated the development of materials (OpenStax, n. d.a). This increase in interest in open textbook content, whether from students or educators, also reflects the broader interest in OER and open educational practices reported during the pandemic (see Bozkurt et al., 2020).

7 Conclusion

Whether emergent or established, open textbook ecosystems are by their nature collaborative and coordinate the actions of diverse stakeholder groups. Whilst open textbooks provide a solution to textbook costs and equitable access, they have also created a timely opportunity for connecting and enabling communities internationally both within and without institutions.

The OER and open textbook ecosystem models explored in this chapter reflect the contextual differences and needs of different communities, as well as the nuances of education systems. As shown by successful, mature ecosystem examples, iterative evaluation of the needs of specific stakeholder groups, an understanding of publisher models, and identification and engagement with current and emergent challenges are vital to ensure a functioning, effective ecosystem. The 'open' aspects of these ecosystems provide further possibilities, and whilst more mature ecosystems provide potential examples for other contexts, these should not be taken as prescriptive or definitive; ecosystems continually develop to both reflect and support changing and emergent practices and needs.

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Resources

Reuse of OER, a Process Model Approach

Robert Schuwer and Marjon Baas

Abstract

The movement around Open Educational Resources (OER) aims to make educational resources available to all through the use of open licenses. Our understanding of the extent of reusing OER, however, is still limited. Measurement of actual reuse is difficult. Much reuse remains invisible and happens under the radar ('dark reuse'). Currently, much attention is given to educational designs where the characteristics of OER (freely available and rights to adapt) are essential (open pedagogy). To better determine which support and skills are needed, a process model for the reuse of OER in practice is developed. This model differentiates between two scenarios: an educator-centred and a student-centred one. Especially the latter scenario clearly shows that support and skills programmes should not only be directed at educators, but also at students.

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1 Introduction

The movement around Open Educational Resources (OER) aims to make educational resources available to all through the use of open licenses. The vast number of OER available in online repositories and the fact that these numbers are increasing continuously shows that sharing OER is commonplace (Bliss & Smith, 2017). Our understanding of the extent to which OER are reused, however, is still limited. While previous studies have explored educators' behavior regarding reusing resources and aligning them with their specific teaching needs within a specific course (Pulker, 2019; Wills & Pegler, 2016; Kimmons, 2015; Windle et al., 2010), these insights are results of funded projects on OER adoption. Yet, projects on OER often cease to exist when the initial funding disappears (Orr et al., 2015). Even though the barriers to OER adoption are known (Cox & Trotter, 2017), our insights into the actual reuse of OER is limited. Only a small number of studies examine OER adoption outside dedicated OER projects, and so-called dark reuse must be considered as well (Beaven, 2018). To improve our understanding of educators' behavior with OER in their daily practice, we must first gain insight into their interaction with the phases of OER reuse. How do educators search and select OER? Do educators adapt resources? And how do they embed them in their teaching or integrate them in their classes?

In this chapter, we present insights into these questions. First, recent research on the different phases of reuse is presented. Next, we describe educational practices where the reuse of OER is an essential part for both educators and students and the implications for educators' and students' competencies. We proceed with describing activities educators and students perform to create their mix of educational resources in a process model. We use this process model to analyse the necessary requirements for optimal support of these activities. We conclude with a discussion of the use of the process model in relation to educators' OER competencies and the consequences for support.

2 Educators' Interaction with the Phases of OER Reuse

Over the years, many studies have examined the different phases of the OER reuse process (Clements & Pawlowski, 2012). The first phase in OER reuse relates to finding OER. Most OER users experience it as a difficult endeavor to find relevant, up-to-date and good-quality OER (Admiraal, 2022). To support educators in finding and evaluating OER, institutes and organisations offer different types of scaffolding. In online repositories, for example, educators are guided by ratings, statistics, and peer reviews to quickly assess OER (Clements et al., 2015). However, research shows that the design and functions of repositories should be further optimized to simplify the search process and further the aims of the open movement (Atenas & Havemann, 2014; Tang et al., 2020). Outside these online repositories, educators can use one of the many scoring rubrics that exist to assess OER (Yuan & Recker, 2015) or, if available, engage with an OER expert within the institute who can help with finding and curating OER (e.g., librarians or teaching and learning centres). Although educators can be supported in finding OER, evaluation of these resources is a more personal matter. Several studies have tried to gain more insights into educators' curational behavior, which can be defined as '*selecting and structuring resources for educational purposes, while providing context and a coherent presentation for a particular audience*' (Leighton & Griffioen, 2021, p. 3). Yet what do educators consider when evaluating resources for possible use in teaching and learning? Leighton and Griffioen (2021) conducted a review study and found that when educators are selecting resources, they appraise the resource on its reliability based on peer reviews and publication date, its pedagogical quality, the quality of the design, and whether the resource aligns with their course objectives. Similar findings are provided by studies that examine educators' criteria for quality OER. For example, Karolčik and colleagues (2017) found that educators identified the correctness and clarity of the content, the ease of use, and clarity supported by examples as key elements of quality resources. Clements & Pawlowski (2012) found that educators define quality resources as resources that are scientifically correct, align with their course content, can be used in their digital environment, and make good use of media. Baas et al (2022) analysed educators' collaborative conversations when assessing OER and elicited five topics that OER were assessed by: content, design, usability, engagement, and readability.

Although these findings show which elements educators could take into account when evaluating OER, educators also have the opportunity to adapt these resources to fit the context of use. This is advocated as one of the advantages of OER. Yet, do educators actually make use of this possibility? Based on an analysis of the dataset of the OER Research Hub (OERRH, 2014), Admiraal (2022) distinguished five types of educators using OER:

- Type 1, called Adapt and Reuse, are relatively inexperienced educators that mainly adapt and reuse all different kinds of OER. Main challenge: finding suitable and quality resources;
- Type 2, called Adapt and Comment, are educators who make comments about the quality of resources and adapt resources to their own needs. They work

relatively often with video materials and images, and less with full courses. Main challenge: lack of time to find suitable resources and to experiment with them;

- Type 3, called Adapt, Create, and Add, are educators that add resources to a repository, adapt resources to their needs, and some of them also create OER. They use mainly videos, images, lectures, and course parts. They reuse OER to obtain new ideas, to supplement their work, to organize self-study for their students, to learn themselves, and to broaden their resources. Main challenge: finding suitable and quality resources;
- Type 4, called Adapt, Create, Publish, Add, and Comment, are relatively experienced, ICT-minded educators that interact with all phases of the reuse process. Main challenge: finding suitable and quality resources, getting acceptance and support from their organization.
- Type 5, called Retain and Consume, are educators who mainly retain and consume OER. In contrast to the other types, they report fewer challenges in finding suitable and quality resources.

What can be discerned from this classification is that almost all OER users adapt resources to their teaching needs. This is in line with a study by Pulker (2019), who found that even if resources align with their teaching methodologies and beliefs, educators adapt, modify, and re-appropriate resources. If educators are content with the adaptations or if no adaptations are needed, they may reuse the resources. They can use OER, both 'as-is' and adapted, in the design of the curriculum, or during the course delivery (Armellini & Nie, 2013). Yet, studies have shown that it is difficult to gain a good insight into educators' adoption of OER due to the ambiguity and unfamiliarity of the term OER (Allen & Seaman, 2015) and, related to this, the influence of so-called dark reuse (Wiley, 2009). Beaven (2018), for example, found that many uses of OER are hidden. Educators might not be aware of using OER or they may be using OER from a personal or a colleague's collection. To gain more insight into educators' use of OER, including dark reuse, Baas and Schuwer (2020) conducted a survey study to obtain more insight into the day-to-day practices of educators when selecting and using resources in Dutch higher education. This study shows that resources that are hard or time-consuming to develop are most often reused by third parties without adaptations while resources that need to be more context-specific are often created by the educators themselves.

As previously mentioned, the possible alignment of retrieved OER with educators' teaching methods and current educational designs is an important selection criterion. However, it is important to stress that the characteristics of OER (open access and rights to adapt) can also have an influence on the educational design. This will, in turn, have an influence on the reuse of OER. This is described in the next section.

3 Open Educational Practices and Open Pedagogy

Being involved with OER is a means to creating an impact in education. Activities leading to such impact are referred to as Open Educational Practices. From 2009 to 2011, the project OPAL ran, partly funded by the EU. In this project, the concept of Open Educational Practices (OEP) was defined as (Andrade et al, 2011, p. 12) (emphasis added by us):

> *"Practices which support the (re)use and production of OER through institutional policies, **promote innovative pedagogical models**, and respect and empower learners as co-producers on their lifelong learning path."*

This definition links educational practices with new pedagogical models and didactical scenarios. Increasingly, the value of OER is not only measured in terms of efficiency or their contributions to qualitative improvements of education, but also regarding the value they have for realizing didactical scenarios that are (almost) impossible without OER. These scenarios are called open pedagogy (Cronin & MacLaren, 2018; Hegarty, 2015) or OER-enabled pedagogy (Wiley & Hilton III, 2018). Clinton-Lisell (2021) describes the many interpretations of open pedagogy as follows (p. 256):

> *"The concept of open pedagogy has had multiple interpretations. A model of open pedagogy with eight key attributes to guide instructors in using OER was developed by Hegarty (2015). These attributes were helpful for open pedagogy but did not necessarily require open licensing to incorporate, such as connected community, peer review, and reflections. This broader approach is contrasted with a more precise approach by Wiley and Hilton (2018) who coined the term OER-enabled pedagogy. OER-enabled pedagogy is a specific approach regarding teaching and learning techniques that are only possible through open licensing (the 5Rs). Similarly, DeRosa and Robison (2017) describe OER use as a "jumping off point" for empowering students with student-centered, process-oriented learning through open licensing. This was further developed by describing open pedagogy as an "access-oriented commitment to learner-driven education AND as a process of designing architectures and using tools for learning that enable students to shape the public knowledge commons of which they are a part" (DeRosa & Jhangiani, 2018, pp. 13–14). In other words, open pedagogy is a method for students to be knowledge creators rather than only knowledge consumers."*

So, one of the attributes of open pedagogy is that students are involved and empowered as co-producers of their learning. This requires students to be open to creativity, to collaborate with peers and teachers, and to be comfortable and self-regulated with less prescriptive teaching approaches (Inamorato Dos Santos, 2019). This requires educators to shift their course designs to include more open educational practices.

When educators are designing an educational setting (in most cases a course), the starting point is that the learning outcomes, the teaching and learning activities, and the method of assessment are aligned, which is known as the principle of constructive alignment (Biggs, 1996). Paskevicius (2017) provides a framework in which elements of Open Pedagogy and examples of OEP are connected in this constructive alignment (see Fig. 1). This model may guide educators to consider and include open pedagogy as part of their course design.

Nascimbeni et al. (2018) introduce the Open Educators Factory (OEF) framework that addresses four open practice areas for teachers, which are design, content development, teaching, and assessment and propose a classification of the capacity of teachers to adopt Open Educational Practices. Regarding educational resources, OER provide access to adaptable and zero cost resources. For example, Hilton III and colleagues (2014) explore cost-savings of OER as an alternative to the burden of expensive commercial resources. In this case, students have

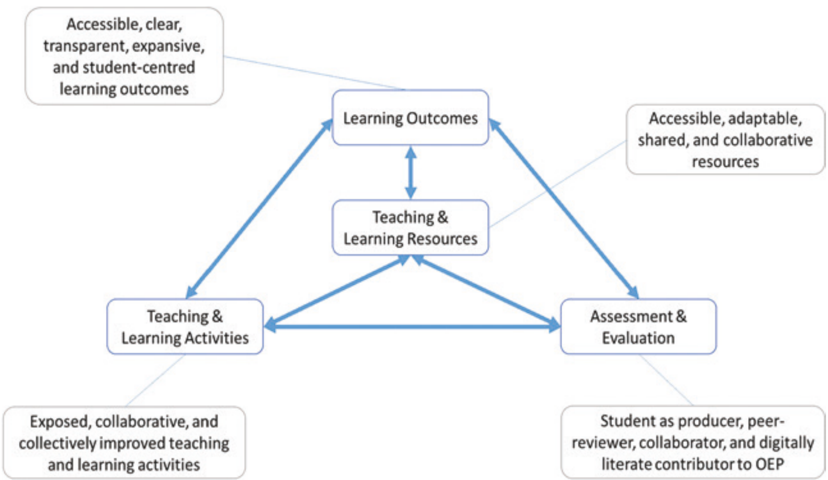

Fig. 1 Aspects of OEP within the model of constructive alignment (Paskevicius, 2017)

the choice which resources they use. We also explored student behavior through focus groups in which 40 students from Dutch higher education participated (Schuwer et al., 2020). Although the majority of students indicated that the literature prescribed by their educators was sufficient for their learning process, the majority also stated they searched for alternative resources to gain a better understanding of the content, to fulfil their needs regarding their preferred media (e.g., video versus text), or to save time by using summaries. Students stressed they were not prepared to pay for a resource that was not included in the mandatory reading list. Instead, if a resource behind a paywall might be of interest, they would look for alternatives, for example by contacting the library or exploring illegal means. Students in the focus group also mentioned the need to find and reuse OER as being an integral part of the educational process they were facing in some courses. In this regard, courses apply student-centred learning outcomes, which is often part of problem-based educational scenarios in which students are expected to find their own learning materials (Savery, 2019).

In reality, educators strive for a mix of educational resources that has the best fit with the learning outcomes to achieve, the didactical and pedagogical principles they will use in teaching, and the type of assessment they will use. This mix of educational resources consists of open, semi-open (only freely accessible for a specific group of people), and commercial materials, digital or on paper.

The educational setting will usually be determined by an educator, but the setting of a student may differ from that of the educator (e.g., by focusing only on a few learning outcomes or by wanting to achieve more than the educator has thought of). In educational visions where more agency is placed with the student (such as OER-enabled pedagogy), the student will primarily determine the set-up of their educational setting and the optimal mix of learning resources that goes with it.

4 Competencies Needed for Reusing OER

To be able to reuse OER, both in more traditional course design as in OER-enabled pedagogies, educators should be competent in using OER. To guide institutes in developing or reusing professional development programmes for educators, the International Organisation of La Francophonie (IOF) (2016) published an OER competency framework. In this framework, five fields of competencies are distinguished:

D1. Becoming familiar with OER
D2. Searching for OER
D3. Using OER
D4. Creating OER
D5. Sharing OER

Each field of competencies covers several abilities an educator should have to successfully include OER in their teaching practices. Fields D1, D2, and D3, and the abilities in D4 that are geared to adapt an existing OER are necessary competencies for OER reuse. Thus, we will zoom in on these four fields of competencies. Table 1 describes the abilities for these fields, with each ability divided into several capabilities.

Even though we refer to this competency framework, we must remark on this framework in relation to reuse. This framework focuses on OER and suggests an important role for specialized OER repositories. Yet, educators also consider freely available resources without the 5R rights as valuable resources to reuse (Baas & Schuwer, 2020). Logically, this means that educators may not only be using specialized OER repositories for finding resources to reuse but may also rely on resources they find on the Web by using common search engines like Google. Consequently, competencies D1 (awareness) and D3.1 (familiar with Creative Commons licenses) are important, especially in case resources are adapted, to avoid infringing on copyright with resources other than OER.

5 A Process Model for Creating and Using an Optimal Mix of Educational Resources

In line with our remark, more insight into the processes of selecting and using educational resources is necessary to advance the adoption of OER by educators. We need insight into their processes of searching, evaluating, adapting, and reusing resources. By mapping these processes, it becomes possible to organize and optimize the institutional support around them including linking the competencies of the described OER competency framework. Although several process models on using OER exist (Hodgkinson-Williams et al., 2017; Schuwer et al., 2010, 2011; Stagg, 2014), these models are either too generic to be useful for the purpose of organizing support or are too specifically geared on one institution and, therefore, difficult to apply within other organizational contexts. Furthermore, as we have described earlier, educators strive for an optimal mix of educational resources consisting not only of OER. We, therefore, agree with Zourou (2017)

Table 1 Educators' needed abilities for reusing OER (extracted from IOF, 2016)

	Ability	Capabilities
D1	Becoming familiar with OER (awareness)	
1	Distinguish an OER from another resource	1. Define an OER in your own words
		2. Name the essential characteristics of an OER
2	List some factors in the emergence of OER	1. Describe the place of education in the Sustainable Development Goals (SDGs) of the United Nations
		2. Identify the actors and triggers that have made OER possible
3	Consider a specific role in the OER movement	1. Identify the "5Rs" that characterize a copyright-free resource
		2. Determine what your contributions could be to the OER movement
D2	Searching for OER	
1	Use a search tool to find OER	1. Understand the meaning of the various terms "bank", "deposit", "directory", and "repository of resources", and be able to recognize them as the sources of an OER
		2. Search for OER on the Internet with simple and advanced search mechanisms by manipulating the search parameters in order to modulate the search results of OER as required
		3. Know the major OER repositories and be able to specify those that are the most suited to your needs
		4. Understand the role played by the standardization of metadata in the interoperability of banks
2	Select appropriate OER	1. Know the quality criteria of an OER
		2. Know the validation mechanisms of the quality of OER
		3. Identify some of the key data in order to correctly attribute an OER
		4. Recognize a license and know how to determine whether a resource has one
D3	Using OER	
1	Distinguish between the different types of Creative Commons licenses	1. Set out in simple terms the comparative advantages offered by Creative Commons licenses
		2. Understand the exceptions to the laws of intellectual property and name at least two that apply in teaching
		3. Identify the four basic options for Creative Commons licenses, know their initials and explain their meaning
		4. Identify at least one of the reasons given by those who oppose the licensing system

(continued)

Table 1 (continued)

	Ability	Capabilities
2	Respect the terms of Creative Commons licenses	1. Use a resource licensed under the Creative Commons licensing system
		2. Demonstrate understanding of the Creative Commons licensing system
D4	Creating OER (adapt or remix)	
2	Revise OER	1. Be able to identify and distinguish a modifiable OER in open format (in particular by ensuring the original design format is available)
		2. Know the different options for adaptation of an OER (translation, sound, illustration, accessibility, contextualization, etc.)
3	Remix OER	1. Know how to create an OER comprising various OER taking into account the specifics of licenses and their potential for dissemination
		2. Know how to create an OER comprising various OER and content that is not open within the constraints associated with this type of composite work and specifying the rights associated with the individual content

who states that '*the value of openness is understood differently and it triggers different types of practice, not always open*' (paragraph 43). We have not encountered process models that focus on the (re)use of open and non-open resources. Moreover, existing models have not included students creating the mix of educational resources. Thus, in this section, we present our process model but first, we will provide some background on the development of this model.

From 2019 to 2022, the innovation programme "Acceleration Plan for Educational Innovation with IT" aims to make Dutch higher education benefit from digitalisation, as it can contribute to the quality of education and strengthen the position of institutes internationally. This Acceleration Plan is divided into eight zones in which 40 universities, research as well as applied sciences, collaborate. One such zone is directed at digital educational resources; open (accessible for everyone without costs), semi-open (accessible for a specific group, without costs), and non-open (only accessible after paying an amount of money). To structure activities within this zone, a process model was developed, based on practical observations and experiences of the project members. The model was refined step-by-step through group discussions. Through several iterative adaptions, an educator's vision of teaching and learning was considered the most distinguishing characteristic that arose from the discussion. This resulted in two scenarios: one aimed at the process of selecting an optimal mix for an educator-centred vision, one aimed at a student-centred vision (like an OER-enabled pedagogy).

The process model shows the activities an educator and a student undertake in order to achieve their optimal mix of educational resources. The two scenarios can be characterized as follows:

- Scenario 1: the **list of educational resources**. The educator assembles what s/he considers to be an optimal mix for supporting the student's learning process and for use in his/her educational process. The educator determines which learning resources are compulsory and which are recommended. The student uses these materials to compile his/her optimal mix. Communication about these resources usually takes place via a list of required and optional educational resources ("the list of educational resources") compiled by the educator.
- Scenario 2: the **instruction**. The educator defines an assignment and usually provides a list of recommended literature. Communication regarding educational resources is more diffuse than in scenario 1. Initially, there will be at least one instruction from the educator to the student that will help compiling the optimal mix of learning resources for the student ("the instruction").

Scenario 1: List of Educational Resources

Figure 2 shows the process model for scenario 1.

An educator will compile a mix of learning resources that best fits the learning outcomes to be achieved and his/her own educational process. That compilation is visualised by the dotted rectangle in the diagram. The educator searches for learning resources that can be either open, semi-open, or non-open (commercial) (Schuwer & Janssen, 2021). Those resources can already be in his/her possession in a private database (generally a hard drive), in a local database (for example a departmental or institutional repository of learning resources, often a shared network drive), or in the "cloud". In many cases, an educator will also create educational resources which also include remixes and adaptations of educational resources found elsewhere. The mix of educational resources will be subjected to a quality control process, which may or may not be explicit. This quality control can also be carried out by people other than the educator (e.g., by peers). Eventually, the mix of educational resources will either be published (i.e., made available to students) or used in educational activities. In the latter case, those materials may not be made available to students, for example, a video that is shown in the lecture hall but that is not distributed further. It may also be the

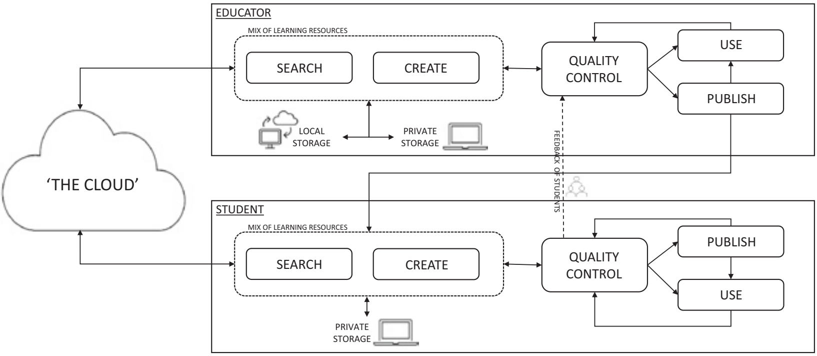

Fig. 2 Creation of an optimal mix of educational resources, process model for scenario *list of educational resources*

case that resources used in the educational activity become available to students. These might include copies of the slides that the educator uses in the educational activity. In any case, publishing the optimal mix of learning resources involves specifying the titles of the resources (usually textbooks) that must be studied and, for each title, whether it is compulsory (the list of educational resources).

Experiences with using educational resources can provide input for a quality check and possibly lead to an adjustment of the optimal mix during or after the course for which the optimal mix is composed. Consider, for example, a situation in which students indicate during an educational activity that they do not possess the prior knowledge the educator assumed existed. The educator can then supplement the optimal mix with educational resources to close the knowledge gap. Feedback on the quality by the students can also take place via a course evaluation (represented in the figure by the dotted arrow).

Based on the published mix of educational resources (including the reading list), the *student* will compile his/her own mix of educational resources. While studying or when participating in an educational activity, the student can search for or create additional educational resources and add these to his/her optimal mix of educational resources. Quality control is expected to be implicit and based on the usefulness the student experiences in achieving the formulated learning objectives. Think, for example, of the experiences the student makes when doing exercises to master a certain mathematical concept. When the student is not able to do all the exercises, s/he will look for additional sources to gain the knowledge that is, apparently, not yet present.

A student may decide to publish parts of their mix for third parties, for example, by making lecture notes available to fellow students in a study group.

Scenario 2: The Instruction

Figure 3 shows the process model for scenario 2.

The activities correspond largely to those described in scenario 1. The educator at least defines an assignment. If necessary, a list of recommended literature for carrying out the assignment is compiled and, if necessary, the educator also produces educational resources. All of this is published and made available to students (the instruction). What was written about quality control on the educator's side in scenario 1 also applies in this scenario. Based on the instructions, the student starts compiling their optimal mix of educational resources.

In this scenario, students can also publish their own (learning) materials (open or semi-open), both in local storage and in the "cloud". An example of this practice is presented in (University Utrecht, 2021). Students in the course Dynamical Oceanography produced several Wikipedia articles about topics from this field.

The student will then also have access to local storage for materials in their optimal mix. This situation arises, for example, when students create and publish educational resources as part of their learning process (e.g., in an Open Pedagogy design). Quality control of the materials to be published can be carried out by both the educator and the student. Conversely, when an educator and students jointly create and publish educational resources (shown by the dotted shape in the figure), the students can also be part of the group that carries out a quality check for the educator.

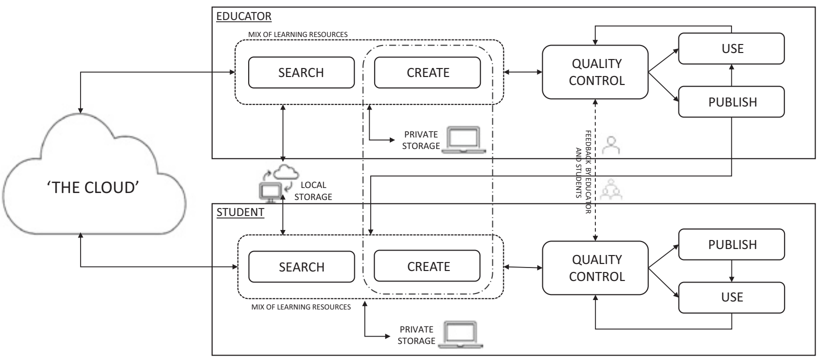

Fig. 3 Creation of an optimal mix of educational resources, process model for scenario *instruction*

Not shown in the figure is the situation where educational resources created by a student during their learning process are added to the optimal mix by an educator the next time the course is given.

As this process model shows the activities undertaken to compile an optimal mix of resources in both scenarios, it provides a broader picture in which reuse is one of the activities. The question that arises is how OER may effectively be reused and which implications this has for the support and professionalisation of educators.

6 Accomplishing Effective Reuse of OER

In this paragraph, we will outline the reuse of OER for each of the scenarios described and derive from this the consequences for the support that needs to be organized and the competencies both educators and students should have to effectively reuse OER.

Scenario List of Educational Resources

In this educator-centred scenario, the added value of OER is mainly that they offer additional, though mostly not mandatory resources. An example of such a scenario are zero-textbook-cost degrees, in which students can opt for open alternatives instead of buying the expensive commercial resources (Bliss, 2015). This is valuable in case students cannot afford to buy the commercial resources. Another possible application of OER for students are additional resources that students can use, e.g., when they need alternative explanations or need more exercises. These resources can already be part of the course design but can also be added by educators during the course as a response to students' needs. In this scenario, students will rarely create OER by remixing or reworking OER with the intention to republish the resulting artefact as new OER. Therefore, competencies in field D4 will only be relevant for educators in most cases, as will be support in this.

Scenario Instruction

In this student-centred scenario, the added value of OER is manifold. Firstly, the instruction may just define some general conditions the result of the learning process should fulfil, with no or only few suggestions for resources. The student will look for OER, but in many cases also for other resources not specifically OER that will help him comply with the instruction. Consider, for example, the instruction "Design a computer programme to support scheduling a football tournament.

Use the C# language to implement the programme". The student will then look for resources to learn about C# (this could be open courses, but also manuals), examples of C# code to reuse (mostly after some adaptation), resources to learn about planning algorithms, and so on. The challenge for them is to determine the quality of these resources. For them, especially capability 1 of ability D2.2 (know the quality criteria of an OER) is important in this scenario.

Secondly, the instruction may contain the task to publish some artefact the students have to create as part of their learning process. These are examples of open pedagogy. The student will not only look for OER, but should also be able to create the artefact, which can include reworking OER. That means they should especially have the competencies of field D4 (creating OER). Consider, for example, the following scenario, inspired by Rutkowski et al (2002): A course in Software Management is split into two parts. In the first part, the course is taught simultaneously at universities in the Netherlands and in Hong Kong, based on the same mandatory literature. For that part, the process model of scenario 1 is taken. In part 2, virtual groups of students are formed, each group including students from the Netherlands and from Hong Kong. Each group is given the assignment to create an open-access website based on a topic from the literature from part 1. For this website, they have to study how the topic is dealt with in practice, both in the Netherlands and in Hong Kong. Part of the website should contain a comparison between both countries.

Which group (educators or students) needs which competencies in this scenario is context-dependent. In contrast with scenario 1, students should have competencies in creating OER (field D4). When educators have no role in creating the artefact, they need not have these competencies. Yet, in specific cases, where students can contribute to an OER in collaboration with their educator, e.g., in creating an open textbook where students will add specific cases, both groups should have the competencies of field D4.

Table 2 maps the activities for both scenarios in the context of reuse of OER for both groups to the competency framework.

The table illustrates what competencies both student and educator should have to effectively reuse OER in their teaching and learning processes. Although this table does not highlight differences between both scenarios, the description from scenario 2 shows that having specific competencies on a more detailed level is context-dependent.

To support both target groups, institutions could also create support teams for both groups. Table 2 shows for which topics support should be organized, depending on whether the stakeholders involved have the competencies. An example is to devise a process where a library provides support for educators in

Table 2 Activities mapped to competency framework

Activity	Competency			
	OER awareness (D1)	Searching (D2)	Using (D3)	Adapt or remix (D4)
Search the cloud	D1.1, D1.2	D2.1, D2.2		
Search local/private storage				
Create/Remix	D1.1, D1.2			D4.2
Create/Adapt	D1.1, D1.2			D4.1
Quality Control	D1.1, D1.2			
Use	D1.1, D1.2		D3.1, D3.2	

copyright clearing (D4.1, D4.2) and searching (D1.1, D1.2, D2.1). Resources to learn about these competencies can be made available as OER. In the spirit of this contribution, reuse of such resources is advised. A search for the term "OER101" provides many examples that can be reused. The context dependency of the need for certain competencies, especially in scenario 2, makes providing support for both groups a challenge.

The analysis also demonstrates that the framework should be expanded to comply with settings where OER are essential for the pedagogy used (open pedagogy). Currently, the framework focuses only on competencies for dealing with the more instrumental characteristics of OER. Yet aligning OER to an open pedagogy requires competencies not listed in the framework. As an example, educators should be aware of the opportunities open pedagogy can offer (an extension of field D1, awareness of OER) and may also be able to look for examples elsewhere (reuse of an idea used elsewhere) (an extension of field D2, searching for OER). The European Framework for the Digital Competence of Educators (Redecker, 2017) provides guidances to include in professionalisation and education programmes. These guidances can also be applied to students.

7 Conclusion

In this chapter, we presented two process models in which the activities educators and students perform to create their mix of educational resources are visualized. We connected these process models with the OER competency framework to support the reuse of OER. Mapping this framework on the process models revealed that not only educators need professionalisation to acquire the competencies, but also students. As yet, no competency profiles for using educational resources are available for students. It would be of interest to examine the work done on students' information literacies and extend it to OER reuse. Especially in scenario 2, where student agency is high, competencies on finding, evaluating, and reusing resources are crucial to succeed in this specific educational scenario. Hence, institutes should consider extending support activities on compiling a mix of educational resources to include not only educators, but also students.

Overall, we may conclude that current trends in OER, moving from a more instrumental view towards a view where OER influence educational design and pedagogy, increase the need for more insight into practices of OER reuse to adequately organize support and skills programmes. These insights define an agenda for the next stage of broadening the reuse of OER.

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Quality of OER: Test Theoretical Development and Validation of an Assessment Tool

Sonja Lübben, Wolfgang Müskens and Olaf Zawacki-Richter

Abstract

Due to their dynamic development process, Open Educational Resources (OER) pose a special challenge regarding quality assurance. While there are many approaches to developing procedures for quality assurance, there is still a lack of suitable instruments to measure the quality of OER. Zawacki-Richter and Mayrberger (2017) integrated seven internationally used instruments for measuring the quality of OER into a comprehensive quality model for OER in higher education. Quality of OER is understood as a multidimensional construct within this model. The model formed the basis for the Instrument for Quality Assurance of OER (IQOER). The article reports on the empirical validation of the German version of this instrument. The validation included the analysis of interrater reliabilities, internal consistencies, and an estimation of construct validity operationalised as convergent validity with the MERLOT Peer Reviewer Report Form (California State University 2019). Furthermore, the particular importance of quality assurance of OER within distributed learning ecosystems is discussed. It is argued that to ensure the quality of OER,

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three conditions must be met: there must be practicable procedures for measuring quality; reliable and valid instruments for measuring quality must be used; and finally, the results of the quality measurement must be communicated to the users of the OER.

1 Open Educational Resources as a Component of Digital Learning Ecosystems

Times when learning processes took place via a central location or channel are increasingly becoming a thing of the past. Instead, in the digital age, the focus is shifting to digital learning structures that support the acquisition of new knowledge or new skills. New technologies, technical infrastructures, and software systems provide the basis for these learning ecosystems. They offer space for content and content formats and support the usage processes. Users play an important role within such learning ecosystems: they are learners, consumers, designers, critics, and providers of impetus and content. By integrating them into the processes and interconnecting them with one another, an active, lively learning culture is created. Through the rapid development of new content, the resulting learning content adapts to new (continuing education) needs, resulting in agile competence acquisition. (Hofschröer et al., 2019).

Because of their free usability and redistribution, Open Educational Resources (OER) offer great potential in this context. In its definition, which was revised in 2015 and is still valid today, UNESCO defines OER as

> "[…] any type of educational materials that are in the public domain or introduced with an open license. The nature of these open materials means that anyone can legally and freely copy, use, adapt and re-share them. OERs range from textbooks to curricula, syllabi, lecture notes, assignments, tests, projects, audio, video and animation." (UNESCO, 2015)

Due to their mostly digital format, OER facilitate agile and formative networking and enable learners to play an active role in educational processes.

1.1 Quality Assurance of OER as a Challenge

However, with free usability and redistribution come new challenges for the quality assurance of open teaching and learning resources. Hirsch et al. (2016) state that, along with copyright issues, the question of the quality of open educational materials is one of the most discussed topics in the context of OER and is central to the acceptance and success of free educational materials.

Yuan et al. (2015) point out that given the growing number of free educational materials available on the Internet, identifying high-quality resources is becoming increasingly difficult. Furthermore, it should be considered that users often evaluate the quality of OER based on personal quality requirements and their own needs, so that quality requirements may vary individually. According to Ehlers (2015), a particular challenge for the quality assurance of OER is the processual nature of the materials. Traditional quality assurance processes establish certain criteria and then check whether these criteria are met. For OER, these static quality checks are only partially effective. Yet it is precisely this openness and adaptability to individual needs that requires special attention when it comes to ensuring the quality of OER: if materials are developed predominantly based on individual needs and subjective criteria, it can be difficult to identify high-quality OER. Here, a quality concept that provides users with at least a basic framework of quality standards could be helpful to make the quality of OER measurable and to strengthen trust in open educational materials.

Distributed learning ecosystems, as described by Otto and Kerres (in this volume), pose special challenges for the quality assurance of OER. Users of OER who access linked repositories via such an infrastructure are often confronted with a multitude of resources on a given topic.

Moreover, these resources do not originate from a single OER portal but from a wide variety of linked sources. Users therefore hardly have the possibility to evaluate the quality of the resources based on their origin. On the one hand, the reputation of the source as indication of the quality of OER is missing, and on the other hand, it is not feasible for users to evaluate the quality standards of a large number of linked repositories and compare them with their own demands.

2 Approaches to Ascertaining Quality in OER

To date, there is no generally accepted procedure or approach for quality assurance of OER. However, the lively discussion around this topic nationally and internationally has led to the development of a variety of different approaches and ways to measure quality in open educational media and to ensure quality assurance. In the following, selected methods are presented.

2.1 Procedures for the Quality Assurance of OER

Many of the approaches to quality assurance of open educational materials relate to their use in the school context.

For example, the base initiative and online platform *"Zentrale für Unterrichts-medien im Internet e. V."*[1] *(ZUM)* relies on a wiki structure for the provision of material, which enables continuous improvement and error correction through comment functions and revision suggestions.

Another method is being tested by the *"edutags"*[2] initiative, which offers a collective tagging system for educational materials on the Internet. The idea behind this is that peer-to-peer tagging makes high-quality materials easier to find.

The *Augsburger Analyse- und Evaluationsraster für analoge und digitale Bildungsmedien (AAER)*[3] offers the possibility to evaluate a teaching–learning medium, to participate in group evaluations of an educational medium, and to view already existing evaluation results. A questionnaire examines a total of eight dimensions (curriculum and educational standards, discursive positioning, macro-didactic and educational theoretical foundation, micro- didactic foundation and implementation, cognitive structuring, picture and text composition, task design, application transparency). The structure of the AAER allows the teachers applying it a differentiated view of the strengths and weaknesses of educational media in the different areas (Fey, 2015, 2017).

Various approaches and ideas for the quality assurance of OER are now also available for the higher education sector.

The *Hamburg Open Online University (HOOU)*[4] promotes the creation of scientific digital learning opportunities and offers free-to-use learning opportunities on its educational platform. The primary basis for HOOU's framework of quality assurance is an evaluation procedure, which serves a supporting and consulting function. The editorial reviews, however, exclusively concern the pedagogical-didactical and technical areas; the content design is the responsibility of the authors. (Friz, 2019). The HOOU is currently developing a questionnaire to

[1] https://unterrichten.zum.de/wiki/ZUM-Unterrichten (as of 27.07.2021).

[2] https://www.edutags.de/ (as of 27.07.2021).

[3] https://aaer.zlbib.uni-augsburg.de/ (as of 27.07.2021).

[4] https://www.hoou.de/ (as of 27.07.2021).

check the quality of its OER.[5] It will examine four different pedagogical-didactical and technical dimensions: content (scientific foundation, target group orientation, reusability of content), didactical design (alignment, collaboration and interaction, application and transfer, assistance and support, assessment), accessibility (CC license, accessibility for people with disabilities, reliability and compatibility, technical reusability) and usability (structure, navigation and orientation, Interactivity, design and readability). As a long-term goal, HOOU has formulated a "brand core" that aims at both, the free and open licensing of OER and the development of an HOOU label for OER as a quality seal. (Zawacki-Richter et al., 2017).

The *Lower Saxony OER portal "twillo"*,[6] funded by the Ministry of Science and Culture of Lower Saxony (MWK), promotes the establishment and expansion of a sustainable infrastructure for the provision of OER. The quality assurance procedure primarily involves an assessment of the materials by the creators themselves. The OER quality check offers direct assistance to users by guiding them through a questionnaire comprising seven dimensions (content reusability, design and readability, structure and orientation, scientific foundation, motivation, assistance and support, application and transfer). In addition to the OER quality check, the twillo portal offers a constantly growing collection of advice and assistance on the topic of quality assurance of OER.

In summary, the presented approaches to quality assurance of OER show an inconsistent picture. As a rule, the responsibility for the quality of OER lies primarily with the authors who publish free educational materials. A number of procedures aim to involve users directly in the quality assurance process. For this, wiki structures, commenting and tagging systems, evaluation, revision, or peer review processes are used. In addition, the OER platform operators provide service and consulting offers as well as editorial support services.

However, a widely accepted model and instrument for quality assurance of OER does not exist. This unsettles many (potential) users. Especially against the background of the increase in digital learning structures and the free usability and dissemination of open educational materials, it is necessary to develop a quality instrument that adequately considers the characteristics of OER (i.e., reusability, modification, processability). (Brückner, 2018; Zawacki-Richter et al., 2017).

[5] The prototype questionnaire can be viewed online at https://www.limesurvey.uni-hamburg.de/index.php/survey/index/sid/161163/newtest/Y/lang/de (as of 27.07.2021).

[6] https://www.twillo.de/oer/web/ (as of 27.07.2021).

For OER used in higher education, the following is an example of the development of a respective tool.

2.2 A Model for the Quality Assurance of OER in Higher Education

In 2017, Zawacki-Richter and Mayrberger conducted an extensive literature review and identified eight international approaches to OER quality assurance:

1. Learning Object Review Instrument (LORI) (Nesbit et al., 2007)
2. Multimedia Educational Resource for Learning and Online Teaching (MERLOT Rubric) (California State University, 2019)
3. Framework for Assessing Fitness for Purpose in OER (Jung et al., 2016)
4. OER Rubric (Achieve Organization) (Achieve Inc., 2011)
5. Learning Object Evaluation Instrument (LOEI) (Haughey & Muirhead, 2005)
6. Learning Objects Quality Evaluation Model (eQNet) (Kurilovas et al., 2011)
7. Rubric to Evaluate Learner Generated Content (LGC) (Pérez-Mateo et al., 2011)
8. Rubric for Selecting Inquiry-Based Activities (Fitzgerald & Byers, 2002)

The subsequent analysis of the identified quality assurance tools for OER showed enormous differences in terms of their respective complexity and levels of detail. In terms of content assessment, two basic groups were identified: the first group offers simple catalogues of criteria or checklists (Framework for Assessing Fitness for Purpose in OER, Rubric for Selecting Inquiry-Based Activities, Rubric to Evaluate Learner Generated Content), while the second group summarises approaches and tools in which the quality criteria are evaluated on a scale. Here, too, differences become apparent: Some of the analysed approaches are based on a quality model with several quality dimensions, to which a number of quality criteria are assigned (e.g., eQNet, MERLOT), yet, no weightings are given to individual dimensions and criteria. Other approaches consist only of lists of criteria (e.g., Achieve). There are additional differences. For example, while the LORI instrument offers a detailed scoring guide for operationalising the rating scales, other instruments consist of simple checklists (e.g., Framework for Assessing Fitness for Purpose in OER). In terms of the context of use, there are generic approaches as well as those developed for a specific subject domain, for example, science (Rubric for Selecting Inquiry-Based Activities), schools (e.g., LOEI), or user-generated content (LGC). (Zawacki-Richter et al., 2017).

It is striking that the number of evaluation criteria varies greatly. They range from eight (Achieve, eQNet) to 42 (LGC). In total, 161 criteria are used in the eight evaluation instruments. To assign these 161 identified quality criteria to a system for a synoptic summary, Zawacki-Richter et al. (2017) extended the quality model of Kurilovas et al. (2011), which was developed within the eQNet Quality Network for a European Learning Resource Exchange. Using this criteria model, they summarised the various quality indicators in the form of a conceptual tree (e.g., Fig. 1). The so-called IPR (Intellectual Property Rights) criteria stand

- Technische Dimension [Technological criteria]
    - Usability
        - Struktur, Navigation und Orientierung [Structure, navigation and orientation]
        - Interaktivität [Interactivity]
        - Design [Design]
        - Lesbarkeit [Readability]
    - Accessibility
        - Zuverlässigkeit [Reliability]
        - Interoperationalität und Kompatibilität [Interoperability and compatibility]
        - Zugänglichkeit für Menschen mit Beeinträchtigungen [Accessibility for people with impairments]
    - Reusability
        - internationale technische Standards [international technical standards]
- Pädagogisch-didaktische Kriterien [Pedagogical-didactical criteria]
    - Content
        - Accuracy
            - Richtigkeit [Correctness]
            - Vollständigkeit [Completeness]
            - Aktualität [Topicality]
        - Adequacy
            - Zielgruppe [Target group]
            - Umfang [Scope/Extent]
        - Intelligibility
            - Verständlichkeit [Comprehensibility]
        - Significance
            - Relevanz [Relevance]
            - Wissenschaftliche Fundierung [Scientific foundation]
        - Coherence
            - Kohärenz [Coherence]
            - Schlüssigkeit [Conclusiveness]
        - Reusability
            - Wiederverwendbarkeit [Reusability]
    - Learning Design
        - Zielgruppenorientierung [Target group orientation]
        - Lernziele und Alignement [Learning objectives and alignment]
        - Engagement und Motivation [Commitment and motivation]
        - Kollaboration, Kommunikation und Kooperation [Collaboration, communication and cooperation]
        - Anwendung und Transfer [Application and transfer]
        - Hilfestellungen und Support [Assistance and support]
        - Orientierung an Bildungsstandards [Orientation to educational standards]
    - Assessment
        - Assessment [Assessment]
        - Feedback [Feedback]
- IPR-Kriterien [IPR criteria]
    - Lizenz [License]

Fig. 1 Indicators for quality assurance of OER (own translation; in accordance with Zawacki-Richter et al., 2017, p. 45)

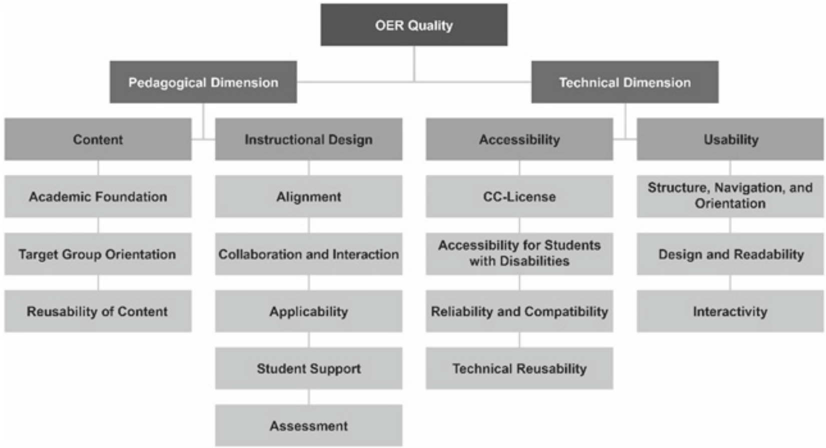

Fig. 2 OER quality model (Mayrberger et al., 2018, p. 29, translated by the authors)

out here, as they are explicitly listed as the main dimensions regarding OER, alongside technical and pedagogical-didactic criteria.

Based on the indicators found, Mayrberger et al. (2018) developed their own model of the quality of OER, which included 15 quality dimensions assigned to the four areas of “content”, “instructional design”, “accessibility”, and “usability” (Fig. 2.).

The model thus describes quality as a complex, multi-faceted construct.

It includes content-related and pedagogical-didactic as well as technical dimensions. Thus, it contains quality criteria that are specific to the demands of the higher education sector as well as requirements that result from the specific dynamics of the development of OER. While the content-related quality criteria ensure that OER meet the expectations of usage in the higher education context, the technical dimensions in “accessibility” enable an open further development of resources as well as the adaptation to specific learning contexts and requirements.

The consideration of “accessibility” quality dimensions guarantees that the dynamic development of quality in the sense of Ehlers (2015), which is typical for OER, is rendered possible.

Most of the individual dimensions in the model also form complex constructs themselves. To make quality validly assessable and measurable, these individual constructs must also be operationalised by objective, reliable, and valid scales. Educational measurement and the associated test and measurement theory are concerned with the development of such scales. Within the framework of the EduArc project, scales for the model of Mayrberger et al. (2018) should therefore be developed and validated using the procedures of test and measurement theory.

3 Test Theoretical Development and Validation of an Assessment Tool

3.1 Instrument for the Quality Assurance of OER (IQOER)

To capture the quality of OER, Mayrberger et al. (2018) propose IQOER, an instrument consisting of a long and a short version. In the short version, each of the 15 dimensions of the quality model of Zawacki-Richter and Mayrberger (2017) is operationalised in the form of a 5-level classification scale (Mayrberger et al., 2018; Fig. 3).

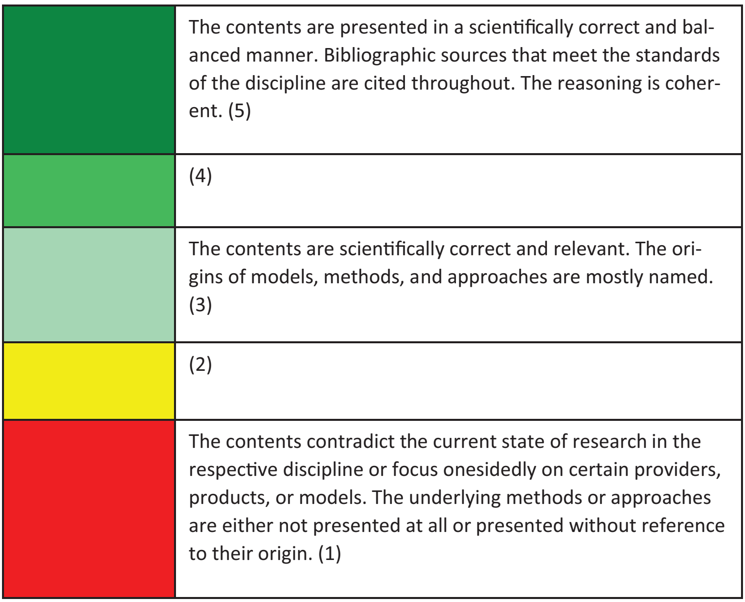

Fig. 3 IQOER (short version): Classification scale “Scientific foundation”; own translation

The dark green level of the classification scales is referred to as the "premium standard" (Mayrberger et al., 2018 p. 21) It should be chosen for resources that are "significantly above expectations". The medium green level (4) denotes resources that are "significantly above expectations", and the light green level indicates the "minimum standard". The lower two levels denote (to varying degrees) failure to meet the minimum standard.

The red, light green, and dark green levels of the classification scales are all described by several statements (descriptors). The intermediate second and fourth levels are not described, so it is up to the raters to interpolate the content of these levels from the other levels.

The assessment of characteristics using individual classification scales is associated with two problems from the point of view of measurement theory:

First, if a characteristic is only determined using a single rating, split-half reliability or internal consistency cannot be determined because there is no other measure to correlate with.

Secondly, and more importantly, a classification scale forces a joint evaluation of possibly incompatible statements. Each classification scale (Fig. 3) consists of several statements that do not necessarily have to be equally true for a particular resource. For example, a resource may well have consistently cited bibliographic sources, but the reasoning within the resource may not be coherent. In such a case, in the example from Fig. 3, the rater is faced with the difficulty of deciding whether the dark green option is right. Ultimately, the rater is forced to weigh the different statements arbitrarily and make a rating accordingly.

For these reasons, classification scales have a very low usage in the empirical social sciences (e.g., psychology), where a measurement-theoretical foundation of the scales is required.

An alternative to classification scales is to average across scores from different individual items. Such items consist of a single statement to which the rater expresses agreement or disagreement on a multipoint Likert scale. The items of a scale are combined mathematically, using classical test theory, by simply taking a mean or sum of the individual ratings (e.g., Wu et al., 2016). If items of a scale have opposite content orientations, they have to be recoded before averaging (e.g., on a 5-point scale, 1 becomes 5, 2 becomes 4, 4 becomes 2, and 5 becomes 1).

Such ratings using Likert scales require raters to make only simple judgments on clear statements about resources. Figure 4 shows the scale "Scientific foundation" operationalised based on five individual items. In this case, the scale is formed by the mean of the item ratings. The alternative "does not apply at all" is

		does not apply at all	does rather not apply	applies somewhat	largely applies	fully applies
1	The OER contains references to subject-specific literature or research findings.	☐	☐	☐	☐	☐
2	The content of the resource focuses onesidedly on specific providers, products, or models.	☐	☐	☐	☐	☐
3	The content is up-to-date, accurate, and relevant.	☐	☐	☐	☐	☐
4	The reasoning in the materials is coherent and comprehensible.	☐	☐	☐	☐	☐
5	The presentation of the content is precise.	☐	☐	☐	☐	☐

Fig. 4 Recording of the scale "Scientific foundation" using individual items based on (Mayrberger et al., 2018, S. 35)

coded as 1, "fully applies" as 5, and the alternatives in between are coded as 2 to 4. Items with opposing content (e.g., item 2 in Fig. 4) are recoded.

Therefore, using the classification scales to operationalise the model by Zawacki-Richter and Mayrberger (2017) serves as a short version of the instrument, whereas the assessment by using individual items serves as a long version. The instrument is referred to as the Instrument for Quality Assurance of OER (IQOER).

3.2 Empirical Validation and Optimisation of the Instrument

The IQOER instrument was empirically tested and optimised in a multi-stage validation study. For this purpose, in a first stage, approximately 50 raters rated 2 OER each using the instrument. The ratings were used to determine interrater reliabilities, internal consistencies of the item scales, and other parameters. Since both, item scales and classification scales were surveyed, convergent and discriminant validities could be determined regarding the two forms of data collection.

To determine the construct validity of the IQOER instrument, raters also assessed the OER using the MERLOT Peer Review Form (California State University, 2019), another instrument for OER quality.

The aim of the empirical study was to obtain suggestions for a revision of the instrument that would allow optimisation regarding test-theoretical quality criteria (i.e., reliability and validity). For this purpose, procedures of the classical test theory were used (Wu et al., 2016).

The validation study is part of an effort to develop a German language instrument to assess the quality of OER. Therefore, all instruments and resources used were in German.

The study was conducted as part of the joint project "Digitale Bildungsarchitekturen—Offene Lernressourcen in verteilten Lerninfrastrukturen [Digital Educational Architectures—Open Learning Resources in Distributed Learning Infrastructures]—EduArc", funded by the German Federal Ministry of Education.

3.2.1 Sample

A total of 50 raters participated in the study. Each rater had the task of assessing two different resources. One rater assessed three resources. In total, 101 resources were assessed. Eight different resources were each rated once, 33 resources were rated by two raters, and nine resources were rated by three raters.

76% of the raters reported being female, 20% reported being male, and 2 (4%) selected the option "diverse". Raters had a mean age of 31.4 years (SD = 9,9).

54% of raters studied or worked in a humanities subject; 28% in a law, economics, or social science subject; and 18% in a STEM discipline. Raters from STEM subjects preferentially received OER with STEM content for assessment. Raters from the other subjects received resources with humanities or social science content.

44% of the raters had a master's degree or a doctorate, 30% had a bachelor's degree, and another 24% were still studying for a bachelor's degree.

12% of raters said they had already been involved in the development of OER themselves, and 48% had experience in the use of OER.

3.2.2 Instruments

3.2.2.1 IQOER

For the survey, slightly revised versions of both, the individual items (e.g., Fig. 4) and the classification scales (e.g., Fig. 3) of the IQOER compared to those published in Mayrberger et al. (2018) were available. The present version differs from the published version, inter alia, in the following aspects:

- An additional dimension, “motivation”, was included. This dimension captures the motivational quality of the resource, the extent to which it is interesting and motivates learners to engage more closely with the content. In the model of Zawacki-Richter and Mayrberger (2017), this scale is assigned to the “Didactics” domain.
- The terms “learning object”, “learning unit”, and “course” were systematised and unified.
- Based on discussions with various German OER platform providers, the items were slightly revised and more focused on the requirements of quality assurance of OER.
- Content inconsistencies between the classification scale levels and items were eliminated.

Only 12 of the 16 IQOER scales were used in this survey. The 4 scales in “Accessibility” require in-depth knowledge of the technical basis of a resource and can, therefore, only be evaluated by technical specialists. Furthermore, these dimensions are only available as classification scales. They were, therefore, not included in the validation study.

Furthermore, not all dimensions of the IQOER can be applied to all types of resources. Five of the selected twelve dimensions involve a pre-selection criterion. For example, for the dimension “target group orientation”, the OER is first assessed with the question: “Does the OER you are looking at contain a reference to a specific target group and/or are required prior knowledge items mentioned?”. Only if the respective criterion is fulfilled, the classification scale and the items are queried. Seven of the dimensions (see Table 2) can be applied to all resources; the scales formed for these dimensions are referred to as the “core scales” of the IQOER (Fig. 5). The results presented here relate exclusively to these core scales.

3.2.2.2 Merlot Peer Review Form

MERLOT (Multimedia Education Resource for Learning and Online Teaching) is one of the most comprehensive and oldest (founded in 1997) OER repositories for higher education in the United States (Malloy & Hanley, 2001; Orhun, 2004). The platform (www.merlot.org) is maintained by California State University in cooperation with a variety of partner institutions and private providers. MERLOT’s quality assurance is based primarily on peer reviews. For this purpose, the platform provides a comprehensive peer review form that is used to evaluate resources (California State University, 2019).

The MERLOT Peer Review Form consists of 31 items in the areas of “Quality of Content”, “Potential Effectiveness as a Teaching Tool”, and “Ease of Use”.

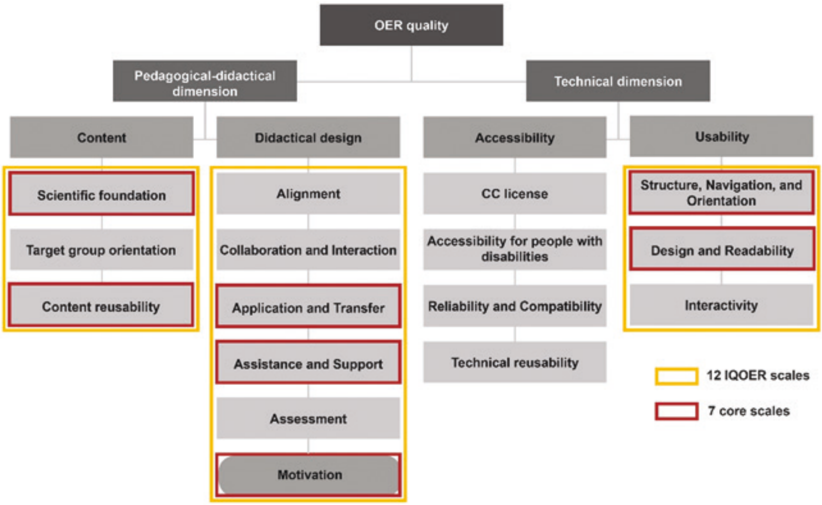

Fig. 5 Dimensions of the IQOER selected for the survey according to the model of (Mayrberger et al., 2018)

Each item is assessed using a five-point Likert scale (ranging from “strongly agree” to “strongly disagree”). A summary overall rating across all three domains is assessed with: “What is your overall numeric rating for this module?”.

3.2.2.3 Assessed OER

This study evaluated German-language educational resources that are published under a CC license and have students at universities or university graduates as their target group. There are 27 OER with humanities or social science content, 7 OER from STEM subjects (science, technology, engineering, and mathematics), and 16 OER with both, humanities/social science and STEM content.

The OER come from relevant public OER repositories (especially from the OER platform of the HOOU Hamburg Open Online University) as well as from commercial platforms such as YouTube.

3.2.2.4 The Online Survey

Raters were given an access code to an online platform. On the platform, they were provided with links to the two OER to assess. They were asked to familiarising themselves thoroughly with the OER and, in case of longer learning sequences, to work through at least 2 chapters of each OER. Immediately afterwards, the raters were asked to access an online questionnaire on the platform. This contained both, the IQOER and the Merlot Peer Review Form in a German online version. Some further items were also collected, which included a general evaluation of the OER.

After evaluating the OER, raters were asked to complete an online questionnaire with demographic questions. For data protection reasons, the demographic data were collected separately and had no link to the OER ratings.

The survey took place from 8/2019 to 2/2020.

3.3 Results

Table 1 shows the 37 items from the 7 core dimensions of the item version of the IQOER (preliminary version).

The correlations between item and classification scales (i.e., r values) reached a sufficient level for all but two items (item 29 "Contents can be found by means of a search function." and item 2 "The content of the resource focuses onesidedly on specific providers, products, or models."). Furthermore, the mean score for item 29 was fairly low at 2.26. The difficulty of this items is very high.

To determine the interrater reliability, an intraclass correlation was calculated between the first and last rating of a resource. Table 1 also shows the interrater reliability of a single rating across all resources. Negative correlations indicate insufficient agreement between raters; this is found in item 15 "In some elements of the OER, at least the first steps of a didactic design are recognisable." and item 24 "The OER contains a summary of the content presented."

The Cronbach's alphas of the 7 item core scales were: $\alpha(SCF) = 0{,}79$; $\alpha(CRU) = 0{,}83$; $\alpha(MOT) = 0{,}92$; $\alpha(AAT) = 0{,}87$; $\alpha(AAS) = 0{,}83$; $\alpha(SNO) = 0{,}78$; $\alpha(DAR) = 0{,}89$.

Table 2 shows the correlations of the item and classification scales. The principal diagonal marked in bold can be interpreted as convergent validity, since item and rating scales represent different forms of measuring the same construct.

Furthermore, Table 2 shows the correlations of the IQOER scales with the Merlot total scale. Due to the inverse polarity of the Merlot scale, negative correlations here mean a correlation in the same direction. All IQOER scales have highly significant correlations with the Merlot scale.

Indeed, it turns out that all convergent validities are substantial and highly significant. Within a row or column in Table 2, the correlations on the principal axis are always the highest values. Thus, in all cases, the convergent correlations (i.e., the correlations within a construct measured across different scales) are higher than the discriminant validities (i.e., the correlations of different quality aspects).

Table 1 Preliminary items of the IQOER (English translation of German items)

Item	Scale	M	r (RS)	ICC
1. The OER contains references to subject-specific literature or research findings	FWF	3.58	.537	.310
2. The content of the resource focuses onesidedly on specific providers, products, or models. (recoded)	SCF	3.55	−.105	.147
3. The content is up-to-date, accurate, and relevant	SCF	4.43	.412	.334
4. The reasoning in the materials is coherent and comprehensible	SCF	4.45	.280	.041
5. The presentation of the content is precise	SCF	4.19	.472	.150
6. The material can also be used in courses or other contexts without modification of the content	CRU	4.00	.717	.459
7. It is stand-alone material, i.e., the use of the material does not necessarily require the use of other materials	CRU	3.93	.572	.234
8. The material can be used flexibly in various learning contexts for a variety of target groups	CRU	3.68	.417	.288
9. The content/the contents of the material are clearly defined	CRU	3.99	.411	.116
10. The learning material is self-contained in its contents	CRU	4.10	.473	.244
11. The design of the OER is unique	MOT	3.06	.834	.179
12. The design of the OER encourages learners to engage with the content	MOT	3.46	.755	.240
13. The contents are arranged in an interesting way	MOT	3.36	.789	.298
14. The OER arouses interest in the subject by its design	MOT	3.13	.756	.117
15. In some elements of the OER, at least the first steps of a didactic design are recognisable	MOT	3.74	.589	-.110
16. The material offers suggestions for applying what has been learned in practice	AAT	3.24	.782	.466
17. The material includes case studies from practice	AAT	3.44	.590	.466
18. Within the material, learners are asked to transfer content or methods to their own (professional) practice	AAT	2.59	.536	.054
19. The material includes theories or methods that can be applied in (professional) practice	AAT	3.49	.519	.189
20. The material contains references to (professional) practice	AAT	3.39	.580	.330

(continued)

Table 1 (continued)

Item	Scale	M	r (RS)	ICC
21. Learners are asked to transfer the presented contents to practical situations	AAT	2.62	.607	.083
22. The material offers assistance on subject-specific terms (e.g., glossary, definitions)	AAS	2.85	.691	.335
23. The resource includes tables, lists, or graphs that summarise or illustrate the topics discussed	AAS	3.34	.605	.179
24. The OER includes a summary of the content presented	AAS	2.90	.530	-.440
25. The OER includes questions that learners can use to check their understanding of the content	AAS	2.78	.635	.542
26. The material includes special advice that supports learning	AAS	2.55	.688	.341
27. The learners always know where they are in the material	SNO	3.81	.704	.352
28. The navigation structure and sequence of the contents are clear	SNO	3.94	.761	.471
29. Contents can be found via a search function	SNO	2.26	.136	.247
30. It is possible to access all previous content at any time	SNO	4.38	.573	.377
31. The structure is simple and clear	SNO	4.00	.855	.563
32. Learners can interrupt the learning sequence at any time and continue later from the same point	SNO	4.35	.377	.128
33. The whole text is easily readable	DAR	4.45	.655	.544
34. Graphics and diagrams are easy to read and can be enlarged if necessary	DAR	3.79	.536	.364
35. All parts of the OER have an integrated, coordinated design	DAR	4.11	.532	.544
36. The presentation suits the content	DAR	4.11	.661	.451
37. All illustrations of the OER are easily recognisable	DAR	4.14	.731	.540

Notes: Dimensions SCF—scientific foundation, CRU—content reusability, MOT—motivation, AAT—application and transfer, AAS- assistance and support, SNO—structure, navigation, and orientation, DAR—design and readability; items range from 1—fully applies to 5—does not apply at all (recoded scales reversed), M—mean, r (RS)—correlation of item with rating scale; ICC—intraclass correlation one way/random, interrater reliability of a single rating; an English translation is provided for each item

Table 2 Pearson correlations of item and classification scales as an indicator for convergent validity

IQOER	IQOER Item Scales							Merlot
Class. Scales	SCF	CRU	MOT	AAT	AAS	SNO	DAR	Total
SCF	**.53*** **	.32**	.28**	.18	.46***	.18	.27*	−.38***
CRU	.35***	**.67*** **	.33**	.32**	.29**	.36***	.48***	−.50***
MOT	.24*	.25*	**.87*** **	.28**	.48***	.23*	.32**	−.51***
AAT	.23*	.07	.41***	**.75*** **	.27**	.20	.18	−.38***
AAS	.37***	.40***	.40***	.31**	**.82*** **	.40***	.38***	−.50***
SNO	.35***	.41***	.38***	.28**	.23*	**.81*** **	.60***	−.56***
DAR	.48***	.48***	.46***	.23*	.31**	.56***	**.75*** **	−.61***
Merlot	−.48***	−.58***	−.64***	−.36***	−.44***	−.56***	−.61***	–

*Notes: $N \geq 85$. * $p<.05$; ** $p<.01$; *** $p<.001$. Scales SCF—scientific foundation, CRU—content reusability, MOT—motivation, AAT—application and transfer, AAS- assistance and support, SNO—structure, navigation, and orientation, DAR—design and readability; Item scales: mean values of the items that were assigned to the scale; Classification scales: separate assessment using a 5-level classification scale; convergent validities are highlighted. Merlot—Merlot Peer Review Form Overall Numeric Rating. Ratings were consistent with conventions for German school grades (high values correspond to low quality)*

Nevertheless, many correlations outside the principal diagonal (i.e., the correlations between different aspects of quality) are also significant. Therefore, the results demonstrate that the different aspects of quality of OER are distinguishable but not independent from each other.

3.4 Interpretation of the Results

The results of this study suggest that the IQOER performed well overall as an instrument for assessing the quality of OER. Both, the short and the long version of the IQOER core scales were able to assess quality aspects of OER that correspond to the quality concept of the Merlot Peer Review Form. This can be interpreted as construct validity for the IQOER.

Furthermore, the item scales all have sufficient internal consistency, which, in some cases, could be optimised with further modifications. In addition, the quality aspects measured have sufficient convergent and discriminant validity (i.e., each of the seven core scales measure separate quality aspects that can be distinguished by the raters). Therefore, the results demonstrate a promising utility of the IQOER instrument.

The analysis at item level also reveals weaknesses of some individual items. Not all items achieved sufficient interrater reliabilities, and some items do not have sufficient discriminatory power regarding the respective scale. The results of the item analysis offer some concrete suggestions for further development of the instrument:

- Due to the negative interrater reliability and insufficient item rating scale correlation, consideration should be given to removing item 2 from the item scale.
- For item 15, the results also showed a negative interrater reliability although the item rating scale correlation is sufficient. It is possible that the wording of the item is unclear; therefore, consideration should be given to rewording the item for clarity.
- Item 18 also has insufficient interrater reliability. Here, the reference to "own (professional) practice" may be problematic; such a reference may be difficult for raters to comprehend and for resource developers to implement.
- Item 24 shows negative interrater reliability. The item should possibly be removed from the item scale.
- Item 29 has low item rating scale correlation and high difficulty. Few OER appear to have the required search function. Therefore, this aspect should possibly be omitted in a revision of the item scale.

A test-theoretical validation of the IQOER thus provided clear empirical clues for the revision and optimisation of the instrument. In the next step, the instrument will be revised according to these findings and then empirically validated again. The revision will result in an instrument with better reliability, validity, and objectivity. Overall, the optimisation of the instrument will lead to better assessment of the quality characteristics of OER.

4 Discussion

The comprehensive quality model for OER in higher education by Mayrberger et al. (2018) addresses both, the subject-specific and didactic demands of higher education institutions and the particular dynamics of the cooperative development of OER.

With the IQOER, an instrument is available for the first time that enables a reliable and valid assessment of the dimensions of this quality model. Thus, from a methodological point of view, a central prerequisite for the introduction of quality assurance measures of OER has been fulfilled.

However, for the quality assurance of OER to actually become effective, further prerequisites must be met.

The first is that quality assurance procedures must be implemented and systematically applied. Especially the providers of online repositories play a crucial role and should develop a quality assurance concept for their resources as publishers of scientific journals do. The examples in Sect. 2.1 show that such quality assurance processes are currently still very inconsistent and fragmented.

Once suitable quality assurance processes based on reliable and valid quality assessment instruments have been implemented, OER portals can ensure the quality of the resources they publish and, thus, build up a corresponding reputation among users. For users, the publication of a resource in such a portal indicates that the OER meets the relevant quality requirements.

In distributed learning ecosystems, however, the situation is more complex: Here, users find a large number of OER from different portals, making it difficult for them to assess the reputation of the source. Here, it is important that the quality of OER becomes transparent for users. Meta-repositories must make quality information visible for users for this purpose. This could be done, for example, by storing the results of quality measurements directly in metadata or by awarding quality certificates as minimum standards.

Lastly, there is a need for further research on how quality measures can be stored, shared, and communicated to users.

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Development of an Austrian OER Certification for Higher Education Institutions and Their Employees

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Abstract

The "Forum Neue Medien in der Lehre Austria" (fnma) is responsible for the development and introduction of a procedure to attest open educational resources (OER) competences and OER activities in higher education. The

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aim is to develop and implement a convincing and recognized procedure that succeeds in sustainably promoting and making visible OER activities and OER competences at Austria's higher education institutions. Within this paper, the development of the Austrian OER certification approach, in other words its framework, will be addressed. A working plan and first results will be presented; among others, the competence framework and its compatibility with existing frameworks.

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1 Introduction

The European Commission is promoting open educational resources (OER), with the aim of “opening up education” and improving the teaching of digital skills in schools and universities (European Commission, 2013). Some define and understand OER more generally as openly available resources – such as MOOCs (Stracke et al., 2019). According to the UNESCO recommendation (2019), openly licensed learning and teaching resources use so-called “open licences”: These licences ease the restrictions of copyright law by allowing everyone to modify, adjust, re-publish, or re-use materials with a few requirements such as attributing the original creator and describing changes. Within the last few years, the Creative Commons (CC) licences have become the dominant licence set in the field of educational resources, so that more and more people use and know the open licences CC BY, CC BY-SA, and CC 0.

International organisations such as UNESCO, OECD, and the European Commission, as well as national initiatives and strategy papers recommend OER development: OER are seen as a base for a more inclusive, open, and sustainable education and world (Orr et al., 2015; UNESCO, 2019). Higher education institutions (HEI) share such ambitions and add some more pragmatic aspects such as OER as solution for copyright issues in teaching, OER providing new teaching opportunities, or OER simply supporting lifelong learning and public relations (Schaffert, 2010; Ebner et al., 2016d).

The topic of OER in HEI is multifaceted, as OER touch many disciplines and different people and responsibilities - e. g., e-learning units, centres for university didactics, central IT services, or university libraries. They are matters of continuing education, of IT infrastructure, of strategies, and copyright issues. “Educational skills”, embedded in the EU’s open science policy (Open Science Skills Working Group Report, 2017) and its eight ambitions, are a key factor in the further development of the Austrian higher education sector. To facilitate open science and open education practices, it is recommended that all scientists in Europe be equipped with the appropriate skills.

To support the development of OER in Austria’s HEI, the project consortium “Open Education Austria Advanced” (OEAA) operates in close cooperation with e-learning centres, central IT services, and libraries of partner universities to generate synergies between open education and open science for the establishment of open practices. Besides the OERhub, a platform under development offering access to OER from Austrian higher education and the development of local institutional OER repositories, the OEAA project team develops and implements the processes of a certification procedure to give OER activities of universities and OER competences more visibility: an OER certification for universities and their staff, i.e., lecturers and instructional designers. The Austrian OER certification project can, therefore, be seen as an accompanying measure to the establishment of a "distributed learning ecosystem" in Austrian higher education (see Otto & Kerres in this book).

2 Aim and Approach of the Article

The aim of this article is to describe the project of developing an OER certification for HEI and their staff to support similar projects to receive impulses and insights. The article is, thus, based on project documentation (partly published, see Schön et al. 2021a, Schön et al. 2021b; Kopp et al., 2021) and the authors' development of a framework OER certification in Austria. The text is structured as follows: Firstly, we describe the background of the development of OER certification and secondly, the project phases. Then we describe the criteria for OER certification as well as insights into our analysis concerning Austrian stakeholders, OER certification, and certification in HEI. Finally, we will present our (preliminary) OER certificate titles, the development of our OER competence framework, and its compatibility to existing frameworks. We would like to point out that the project is in development and that there may still be changes to the preliminary results.

3 Background of the OER Certification, the Implementation Phases, and Criteria

3.1 OER in Austrian HEI

There have been several contributions describing the development of OER in Austria (Schön & Ebner, 2020; Schön et al., 2017); we focus here on the status of OER in relation to higher education. In general, Austria is a German-speaking country of about 8.8 million inhabitants. Most students are enrolled at HEI that are publicly funded and can be attended for comparatively low tuition fees - especially in international comparison - if one meets the formal admission requirements. Austria counts 22 public universities, 16 private universities, 21 universities of applied sciences, and 14 universities for teacher education.

Like the worldwide OER movement, individuals and groups started to develop and work on the idea of freely available and usable learning content in the first decade of the 2000s. A first Austrian milestone was the coordination of an international conference on open educational content in 2007 as the final activity of the first European project focused on OER (olcos.org; led by Salzburg Research[1]). In general, Austria belongs to the countries where OER production or use are part of government policy (Orr et al., 2015, p. 129). OER have been mentioned in several Austrian national strategy papers in recent years. One example is the "General Austrian University Development Plan" (own translation), which is the planning instrument for the further development and strategic orientation of the 22 public universities (Bundesministerium für Bildung, Wissenschaft und Forschung, 2020, p. 40, cf. Schön et al., 2021c).

An essential institution for the exchange on the topic of OER in the Austrian higher education sector is the "Forum Neue Medien in der Lehre Austria" (fnma for short, see www.fnma.at), especially their special interest group (SIG) for OER. fnma is a non-profit organisation and the Austrian network for the development and implementation of strategies and recommendations in the field of digital learning and teaching in HEI. Nearly all Austrian higher education institutions are members of the association led by an executive board of six experts. These are elected by delegates of the member universities. The executive board of the non-profit organisation is supported by an executive director and several part-time employees. As the only Austrian inter-university interest group for the use of digital media in teaching in HE, fnma is also an important contact point for the Federal Ministry of Education, Science and Research and the public. Recommendations by the fnma special interest groups on various topics are also relevant for political decisions. The first meeting of the special interest group on OER took place in 2015.[2] All interested members of partner universities can participate in the fnma SIGs. Two joint contributions have been published: In one, recommendations for the introduction of OER in higher education are given (Ebner et al., 2016a, 2016b). In another, a certification of competences of university staff as well as of the universities' activities is proposed (Ebner et al., 2017; Ebner, 2018). Representatives of the Federal Ministry of Science, Research and Economy and

[1] Salzburg Research Forschungsgesellschaft mbH is a non-profit research organisation owned by the State of Salzburg, see https://www.salzburgresearch.at/.

[2] https://www.fnma.at/arbeitsgruppen/open-educational-resources.

the Association of Austrian Librarians were also active contributors to these publications.

The Austrian Ministry of Education, Science and Research funded a first project on OER infrastructure at Austrian universities, called "Open Education Austria", with four partner universities in 2017. In May 2017, fnma organised the first Austrian OER festival for HEI at the University of Graz in cooperation with the Open Education Austria project. In 2020, the project "Open Education Austria Advanced" started to further develop OER infrastructures, such as OER repositories, OER training, services for lecturers for OER creation, and the OERhub.at, an Austrian one-stop shop for OER in higher education, hosted and developed by the University of Vienna.

Numerous smaller initiatives or OER projects at Austrian universities show that OER are becoming increasingly important and attracting. OER are more and more perceived as a field of action by Austrian universities, which is also reflected in the results of an analysis of the current performance agreements (valid for the period from 2019 to 2021) of the 22 public Austrian universities (Edelsbrunner, Ebner & Schön, 2021): Nine out of 22 performance agreements (41 percent) already describe concrete OER activities, three others at least mention OER or related concepts.

3.2 The OER Certification Implementation Project as Part of Open Education Austria Advanced

"Open Education Austria Advanced"[3] started in April 2020 and will last for four years. The University of Vienna, the University of Graz, Graz University of Technology (TU Graz), and the University of Innsbruck work together with fnma and öibf[4] (a non-profit research institute in the field of professional research) as smaller partners work together to expand their services for the development of OER in HEI. One work task of "Open Education Austria Advanced" is the implementation of an OER certification. It is seen as a service for the universities to intensify recommended OER activities while simultaneously evaluating these activities independently and making them visible. As project partner of

[3] https://www.openeducation.at/ueber-uns/.

[4] https://oeibf.at/en/.

the OEAA project, fnma, together with öibf and TU Graz, is responsible for the development of the OER certification development and implementation.

3.3 Project Aims and Phases

In cooperation with all Austrian stakeholders, the necessary procedures and processes have been set up and implemented since March 2020 and will be finished by February 2024. Latest by the end of the project period, all Austrian HEI should be able to apply for an OER certification for their staff as well as for the HEI itself. The aims of developing a certification procedure for HEI and their staff are to promote and to make visible the offer of continuing education on OER, the OER competence development of staff, and the OER development and OER activities of a HEI. Therefore, the project attempts to develop a convincing and recognised procedure that is not unnecessarily complex and does not need extensive documentation work, but rather a comprehensible framework and objective processes for HEI. The development phases of the OER certification are shown in Fig. 1.

For the entire duration of the project, it is planned to develop and implement the OER certification in close cooperation with the active members of the SIG OER, i.e., in regular meetings for development and discussion, and to make the development comprehensible for the public and present it in a national and international environment. Additionally, thinking beyond the project timeframe, we are also developing a business model that enables the long-term operation of a certification body beyond April 2024.

3.4 Criteria for the OER Certification

Regarding the criteria for certification - probably the aspect with which many would expect the project to start - the starting point was the mentioned publication by the SIG OER, “Concept of OER certification at Austrian universities”

Fig. 1 The project phases of the Austrian OER certification implementation for HEI. (Source: Own illustration)

(Ebner et al., 2017; Ebner, 2018). The concept for OER certification outlines the certification of both university staff and HEI and recommends the creation of a national certification body. To this end, the SIG OER has developed criteria that promote useful measures for HEI for building OER infrastructure and competences, while being comparatively easy to track. As shown in Fig. 2, the criteria for HEI are an existing offer of continuing education on OER for their staff and a public and strategic commitment to OER, an OER repository (or access to a joint solution), and a certain number of certified OER individuals. HEI can apply for an OER certification of members of their staff if there is proof of their participation in an OER training with an effort of one credit according to the European credit transfer system (ECTS) (about 25 h) and three published OER per person. (Ebner et al., 2017; Ebner, 2018).

It is not planned to validate existing competences of OER as part of the criteria, but proof of participation at a training with a certain extent (25 h) is required. In Austrian continuing education for university staff, participation is usually certified, but a final exam or validation of competences is rather rare. For an OER certification, the individual staff member must prove that they participated in a relevant comprehensive training measure and have published three OER.

As part of the OEAA project, fnma has been commissioned to establish the national OER certification body and processes for certification with the support of its project partners. At the beginning, in March 2020, there were only two HEI that already (potentially) met the requirements for one criterion: The University of Vienna (Marksteiner, 2008) as well as the Graz University of Technology have repositories where OER can be published and archived (Ladurner et al., 2020).

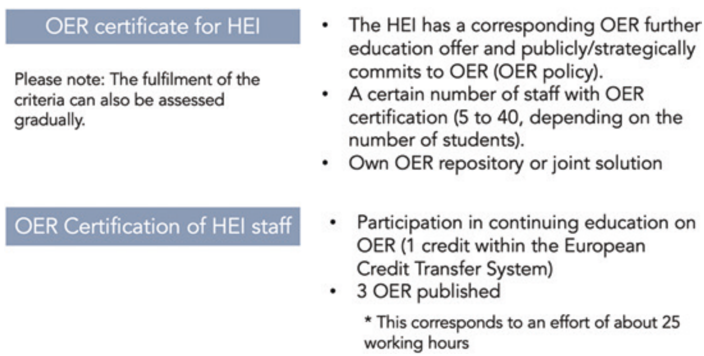

Fig. 2 The criteria for Austrian OER certification. (Source: Own illustration)

Other criteria, such as a public commitment to OER or an OER policy were not met by Austrian HEI at the project start. Nevertheless, as we know from the SIG OER meetings, several HEI—including universities of applied science and university colleges for teacher education—already offer continuing education on OER for their lecturers. For the most part, however, the training does not reach the extent of 25 h. This description of the status quo at the start of the project shows that the criteria for OER certification at universities are indeed challenging: No university met more than one criterion.

3.5 The OER Certification Implementation

At the start of the project, it was again scrutinized whether the criteria (Ebner et al., 2017; Ebner, 2018) were still well chosen. However, it was decided that the validation of competences could be part of future revisions. To better describe the prerequisites of continuing education on OER, it was decided that a competence framework was an important measure. For other criteria, too, it seemed necessary to define more precise descriptions and prerequisites, for example, what exactly is meant by "published OER".

So, focusing on the OER certificate, as shown in Fig. 3, the situation at project start was as follows: We will build on the existing criteria, but need to specify them; it is necessary to determine the title of the certificate, how we will call the certificate holders, and the design of the certificates (from a logo to the possible technical implementation, for example, as an open badge), and to develop the process. A validation of informally acquired OER competences of individuals or a systematic extension of the certification to other target groups (such as students), educational sectors, or countries is explicitly not planned in the project.

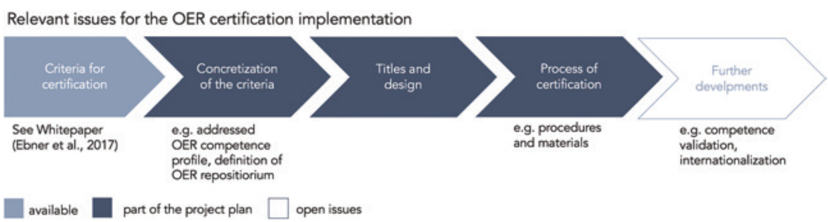

Fig. 3 Relevant issues for the OER certification implementation within the project time frame (2020–2024). (Source: Own illustration)

4 Related Analyses: OER Certification, Certification in HEI

The project included an internal stakeholder analysis to involve all relevant institutions and people in the development of the certification, to use their potential as multipliers or to be able to consider their needs and concerns at an early stage. Besides this, we searched for other OER certifications available at (Austrian) HEI.

4.1 Existing OER Certifications

Starting from our national context, we searched and collected examples of OER certifications for lecturers and adult educators worldwide. Among the examples we found (Schön et al., 2021b) were MOOCs where participants receive a certificate upon finishing, such as the first course on OER in German (Arnold et al., 2015), small OER training offers and, perhaps most prominently, the Creative Commons certification (Creative Commons, 2021). We were unable to find an OER certificate for HEI or other organisations that certifies an institution that is particularly concerned with OER and demonstrates activities according to defined criteria. However, we did find a few procedures that seem to be inspiring, such as a contribution describing a competence framework or activities of universities regarding "Opening Up Education" (Inamorato dos Santos et al., 2016) or the OERu network, where it is possible to participate for a fee. The network is primarily concerned with supporting and disseminating MOOCs that provide OER. It is, therefore, not a certification process in the strict sense (OERu, 2021). The collection has shown us that there are—and should be—strong efforts to make the requirements and processes transparent, especially in OER certification.

4.2 Certification of and Within Austrian HEI

An internal report compiled how Austrian HEIs are currently certified. The starting point was the institutions' self-presentations. A large number of international certificates were found, e.g., for quality management and environmental protection, but also Austrian certificates for family-friendliness. Obtaining a certification is usually time-consuming for HEI; in addition to concrete activities, visits by commissions and extensive audits are necessary. We also looked more closely at how continuing education is organised in Austria for HEI members, particularly in the OER-related area of continuing education in technology-enhanced teaching.

The universities of applied sciences offer continuing education throughout Austria; moreover, regional cooperation for continuing education has been established among different HEI in Styria (Kopp et al., 2016). However, there is neither a common continuing education system in the field of technology-enhanced learning or higher education didactics for HEI in Austria, nor a structure where continuing education certificates are mutually recognised. The implementation of an OER certificate for individuals must, therefore, take place in several different organisations.

5 The OER Competence Framework and Its Compatibility with Other Frameworks

5.1 The Austrian OER Competence Framework for Individuals in HEI

In the first months of the project, a competence framework was created to establish a set of competences relevant for the certification. A competence framework is a model that lists the competences of individuals required to perform specific tasks within an organisation or sector (Marrelli et al., 2005). It includes a qualification description for the certificate holders, which was created based on a thorough review and comparison of existing OER frameworks and developed and agreed on by the fnma SIG OER and other stakeholders. Practically all OER courses and frameworks include open licenses, how to find OER, how to create OER, and how to remix OER (see, for example, the OLCOS tutorials from 2007: Córcoles et al., 2007). We, therefore, used existing OER competence frameworks for orientation (see below). Our wording of a "qualification description" and "learning objectives" is based on the specifications of the national qualification framework for Austria (NQR-Gesetz, 2016). In several discussion rounds, we adjusted the general qualification description and the learning objectives (see Fig. 4).

5.2 Comparison with Other Existing OER Competence Frameworks

Before we asked the SIG OER for final approval of the competence framework, we looked at how well our version is compatible with other competence frameworks, especially with well-known national and international competence frameworks. During our work, we discovered the following competence frameworks that deal with OER specifically:

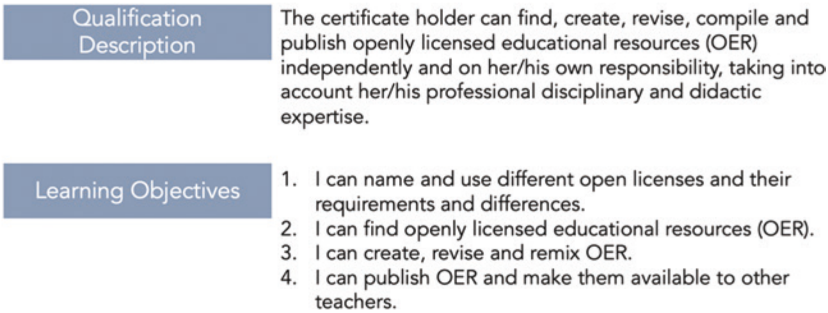

Fig. 4 The competence framework of the Austrian OER certificate for individuals. (Source: Own illustration.)

The Organisation Internationale de la Francophonie (2016) published an "Open Educational Resources Competency Framework OER". This framework has five "fields of competences", which are "becoming familiar with OER", "searching for OER", "using OER", "creating OER", and "sharing OER". For each field of competences, the authors describe abilities and capabilities. For example, the competence field "searching for OER" lists the ability "Select appropriate OER", which is described with the capabilities "1. Know the quality criteria of an OER, 2. Know the validation mechanisms of the quality of OER. 3. Identify some of the key data to correctly attribute an OER, 4. Recognize a license and know how to determine whether a resource has one" (p. 4f). A comparison of the learning objectives of the Austrian draft with this OER competence framework does not show any deviations, rather, the OER competence framework appears to be helpful in specifying capabilities.

Nascimbeni and Burgos (2016) developed the idea of an "open educator" in HEI and defined him/her in the following way: "An Open Educator choses to use open approaches, when possible and appropriate, with the aim to remove all unnecessary barriers to learning. He/she works through an open online identity and relies on online social networking to enrich and implement his/her work, understanding that collaboration bears a responsibility towards the work of others" (p. 4). The "open educator" is described by different characteristics and mentions four facets of open education, namely design, content, teaching, and assessment. OER are in the "content" facet (p. 9). Such an "OER expert" is characterised as follows:

- Re-shares resources that he/she has reused openly through social media and OER repositories.
- Uses resources created by others.
- Searches for OER through social media and repositories.
- Shares and promotes resources produced by his/her students.
- Shares links and resources beyond the classroom, through an open online identity.

In comparison, the characteristics in the Austrian OER competence framework are more concretely oriented towards the correct development and use of OER than towards characteristics of lecturers ("open educator").

Ehlers & Bonaudo (2020) have also proposed a competence framework for "open educators" that consists of two components: competences related to OER and competences related to "Open Pedagogies" (p. 73ff). Regarding OER, they distinguish four competences:

- Use open licences
- Search for OER
- Create, revise, and remix OER
- Share OER

Ehlers & Bonaudo (2020) have, thus, merged the characteristics of the open educator from Nascimbeni and Burgos (2016) with concrete requirements for OER competences.

In summary, a congruence of existing OER competence frameworks and the Austrian OER competence framework is obvious.

5.3 Comparison with Other National Competence Frameworks for Teachers and Educators in HEI

There are several other competence frameworks that are interesting to compare to the OER framework for the Austrian and international context. In the following, we list some that are of special interest from an Austrian perspective:

- The research centre of the European Commission JRC has developed a competence framework for digital competences of teachers, the DigCompEdu competence framework (see Redecker & Punie, 2017, 2019). Teachers should have certain competences regarding the use and creation of digital resources (Redecker & Punie, 2019, p. 15). This section is not exclusively about OER, but OER are explicitly mentioned, including the use of open licences. There are also further aspects of "digital resources" that play an important role for teachers in general, such as data protection. The description in DigCompEdu is, therefore, somewhat broader overall and does not only refer to OER, though it does mention them explicitly.

- The same is true for the Austrian framework for digital competences for teachers. In the Digi.kompP model, "creating digital materials" is described in "Category C", which is "designing, modifying and publishing materials for teaching; use of works and copyright" (Onlinecampus Virtuelle PH, 2019). Thus, practically all competences of the OER certificate are also included in the Austrian competence framework of Digi.kompP for teachers, but it does not specialise on OER.
- The German competence framework for digital competences for university teachers does not mention OER specifically at any point but includes the creation of learning resources and, as such, aspects of open data and copyright (Eichhorn & Tillmann, 2018, Digitale Kompetenz bei Hochschullehrenden, n. d.).
- The "Digital Skills for Library Staff and Researchers Working Group" of the European Librarians' Association LIBER (Ligue des Bibliothèques Européennes de Recherche - Association of European Research Libraries) has defined skills and abilities needed for Open Science. OER are also named in the "Open Science Skills Visualisation" several times as a partial aspect of Open Science (McCaffrey et al., 2020; cf. Stracke, 2020).
- Competences in the field of Open Education are also embedded in one of the eight ambitions of the EU's Open Science policy as part of educational skills for researchers (O'Carroll et al., 2017). According to this policy, these skills in the context of training and lifelong learning enable researchers to perform a change in mind-set and culture, while also modernising the higher education sector. OER competences belong to the set of appropriate skills for facilitating Open Science, alongside open practices such as open access, open data, open peer review, and citizen science.

To sum up, there is intentionally congruence with other competence frameworks for teachers and researchers at universities, which makes it possible to use the OER certifications framework for continuing education programmes or validation schemes in the fields of digital competences of teachers and Open Science; nationally as well internationally.

6 The Certificate, Its Title, and the Further Development and Continuous Training Offers in the Project

6.1 Consensus-Based Decision on Titles

While the criteria for certification have already been described, work is currently underway to outline the processes and the design of a suitable digital environment. To increase the impact and incentives for the certificate, it is planned to meet as many standards as possible in the development and, thus, to create compatibility with national and international initiatives and certificates, among other things by considering the quality standards of the Deutsche Gesellschaft für Hochschuldidaktik (2020). Whether and how the certificate will also be awarded in the form of virtual "seals" or open badges is still open.

To determine the title of the certificate for individuals in HEI and the HEI themselves, a consensus-based online survey was conducted among the SIG OER and OEAA project colleagues. A long list of different options from "OER expert" to "OER master" was presented and respondents were asked how much they disagree with these options. The point of this survey was not to determine which title receives the highest approval, but which title receives the least opposition. The result – the title with the least opposition – was "OER practitioner". For HEI, the title with the least opposition is "Certified OER university". Both were approved as the titles for future certificate holders.

6.2 Development of Procedures

During the current phase, the concrete procedures and materials will be developed together with the pilot partners. The framework conditions include the fact that we need an independent advisory board that decides, for example, whether a continuing education program meets the requirements. So far, we have only set a competence framework and the requirement of one ECTS and would now like to see which and how pilot partners can present documents that also convince the advisory board. In practical terms, it is also a question of who must provide what data or information; for this, we need data protection declarations, etc.

6.3 Additional Support of Continuing Education on IER in HEI: Materials, a MOOC, and a Train-The-Trainer Model

OER certification can only be one building block in an OER landscape. Closely linked to this is the creation of suitable continuing education offers for teachers and other staff and the appropriate qualification of trainers. In cooperation with other Austrian universities, the University of Graz will revise the existing online course on open educational resources on the Austrian MOOC platform iMooX.at. This platform is itself dedicated to OER (Kopp & Ebner, 2015; Ebner et al., 2016c). Since 2015, courses on OER have been offered on the platform, and a special MOOC for OER in HEI was implemented in 2017 and has been offered three times since (see https://imoox.at/course/coer2019; Ebner et al., 2016c).

Within the Open Education Austria Advanced project, the MOOC in question will be re-developed and produced according to the competence framework described above. The MOOC and its contents - organised in four units with an estimated 16 videos (available on YouTube.com), materials such as an OER canvas, and quizzes - can be integrated partly into an OER training at a university. Participants who successfully complete the quizzes for each unit will receive a certificate of attendance and open badges for MOOC participation (Kopp et al., 2021).

In practice, in the last few years, several universities have organised their internal OER trainings for teachers and staff with a first half-day workshop, the MOOC participation as an online phase, and another half-day workshop to clarify open issues. HEI can, thus, verify that a person took part in continuing education to the required extent of one ETCS (25 working hours). Besides a self-study MOOC, an additional offer is planned to meet the requirement of one ECTS (25 working hours) of continuing education as defined in the certificate criterion. For this special course, the participants will use a specially implemented course space at the MOOC platform with assignments, feedback options, and peer reviews, which will require the time and effort needed for a certification.

HEI offering continuing education on OER are free to choose their lecturers and the precise contents. However, to have enough qualified people in Austria who can be hired by HEI, it is planned to offer a train-the-trainer course for the first time in 2023.

7 Developments Regarding the Criteria of the OER Certification and Outlook

In Sect. 3.1, we described that at the beginning of the project in April 2020, only some HEI fulfilled at least one of the OER certification criteria. Progress has already been made here (as of November 2021): After the project launch in March 2020, two universities have already published OER policies: The University of Graz was the first Austrian university to have its own OER policy by a decision of the rectorate in March 2020. It was followed by TU Graz in November 2020. At least two more universities will follow in 2021. Some recommendations have been published for universities that plan to develop OER policies (Ebner et al., 2020).

Concerning the OER repositories, two OEAA partner universities will implement their OER repositories in the project and other Austrian HEI are engaged in their own developments or potential joint solutions. OER repositories at Austrian HEI are currently available at the University of Vienna (Marksteiner, 2008) and at the TU Graz (Ladurner et al., 2020). At the University of Innsbruck and the University of Graz, such a development is part of the Open Education Austria Advanced initiative.

Although continuing education on OER is offered at several HEI, an OER training with an effort of about 25 h is still more extensive than currently available offers, compared with training in the field of technology-enhanced learning. It is not easy to convince the HEI management and the potential participants of this, and it is, thus, not quite easy to reach the number of individuals needed for certification (5–40 individuals per HEI).

To sum up, the development of an OER certification procedure for HEI in Austria is a balancing act: it is not just a simple matter of assessing and rewarding existing developments, but also of actively stimulating and promoting them. The selected criteria are, indeed, ambitious and cannot be completely fulfilled by a HEI during the project period without further adaptations or without difficulties. The certification criteria can also be seen as a measure to put the focus on important activities, for example, an OER repository that can be used by all Austrian HEI.

8 Aim for International Cooperation

With our activities and results,[5] we are hoping to promote the Austrian development of OER certification for HEI in the long term, possibly also with transfers to other educational sectors, to create an international network and, thus, to make an essential contribution to good teaching and open education.

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Future Directions in OER

Royce Kimmons and Julie Irvine

Abstract

Open educational resources (OER) are revolutionary for shaping our distributed learning ecosystems (DLE), but only if we avoid technocentric narratives of OER as having effects themselves. Rather, we must focus on exploring the opportunities provided by open technologies and resources to allow us "to rethink what learning is all about, to rethink education" (cf. Papert, 1990) and actively work to reshape our institutions in concert with possible futures. This rethinking and reshaping are not only limited to how we understand the impact of OER but also how educators can more feasibly create and use OER and how we make a better and more equitable world. This chapter will explore some of the emerging possibilities offered by OER to rethink how we have approached education in the past and how we can use OER to move toward futures that allow for more sustainable generosity.

As we look forward to the potential open educational resources (OER) have to positively shape distributed learning ecosystems (DLE), we must first consider the history of OER and acknowledge how technocentric thinking can negatively impact education systems. Our recent history of educational technologies is

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saturated with missteps, misfires, and unrealized utopian thinking (Watters, 2021), wherein educational technology research seems to follow a general trend of adopting technologies first and only later exploring matters of instructional effectiveness, pedagogical use, ethical considerations, and social effects (Boekweg et al., 2021). This technophilic or technocentric (Papert, 1990) view of educational technology treats technology as a catalyst or change agent upon education, wherein new technologies are expected to have an improving or even revolutionary effect on both individual learning and complex educational systems. The problem with this view is that it is both overly optimistic in its expectations of the positive effects that technology can have on education and simplistically assumes that technology is the change agent that acts upon social institutions, which are seen as passive recipients. In this view, technology is the chisel, and society is an amorphous block waiting to be shaped. In response, we, and others, have argued that the proper way to understand technology's relationship to education, scholarship, and society is to view it as a coevolutionary artefact, wherein technologies and social institutions recursively shape one another, because emergent technologies "may just as validly be seen as a reflection of cultural trends as a cause of them" (Veletsianos & Kimmons, 2012b).

Applying this principle to OER and what the future holds for our DLE, we should first recognize that a cyclical relationship exists between OER and DLE. OER may technically enable us to do certain things, but even our understanding of OER is shaped by the values and norms present in our DLEs, as we then allow these values and norms to shape, empower, or negate what OER can be. The history of open-washing (Weller, 2013; Wiley, 2011) and the xMOOC (as opposed to the cMOOC; Ping, 2013; Xibin et al., 2013) are both prime examples of how OER may influence some changes in educational systems, but those same systems have the power to shape (and potentially warp) our understanding of what openness means, as open technologies and practices can be turned against themselves to promote futures that may be antithetical to the basic tenets of openness.

The problem with this recursion as it relates to OER is that tools and ideas that have the potential to help us fundamentally "rethink what learning is all about" (Papert, 1990) often end up being colonized or co-opted by existing systems to move forward business-as-usual. The reason for this is obvious: no system can be self-revolutionary. No system can be set up to allow for its own demise, and the pain, struggle, and inefficiency of a revolution only ever seem wise if we can be certain that the new system will be significantly superior to the old (cf. Kuhn [1996] and the precursors to scientific revolutions). As a result, revolutionary ideas and movements must often choose between (a) fighting a perpetual battle against a status quo that is mature and works more efficiently than the immature and untested revolutionary alternative or (b) reshaping themselves into docile or ineffective cogs in the machinery of the system. In our case, if we view the DLE as our system, it seems that the radical notions of openness that undergird OER must either seek to fundamentally change how DLE operate or risk becoming nothing more than a moral signal that appears to be responsive to the times without making any fundamental adjustments.

Or is there another possible future? We think there is, but to achieve it, we must start by taking a step back and reminding ourselves why we care about openness to begin with.

1 Openness as Means Versus End

Openness is not an unequivocal good. You would be rightly perturbed if your physician openly shared your medical history, if your romantic partner openly aired your relationship's dirty laundry, or if your bank account were open for anyone to access. Openness, as with many of its synonyms like transparency and sharing, is good for achieving some particular ends, but the same idea that might be good in one setting (e.g., sharing our food with the needy) would be irresponsible or unethical in another (e.g., sharing COVID-19 with our students). Though we are quick to laud the utopian benefits of openness, we sometimes fail to equally articulate why openness is beneficial, why we want it, and in what contexts. We also often treat openness as an all-or-nothing proposition: either you promote open futures or you do not.

Most philosophical discussions of openness start from a place of altruism, access, equity, democratization, selflessness, or generosity. These ideals appeal to "fundamental ethical behaviours" and "moral requirements" to animate openness as a practice (Veletsianos & Kimmons, 2012a). Of these foundational ethics, we find "generosity" to be the most useful (cf., Wiley, 2010) because it is synonymous with some terms (e.g., "selflessness," "altruism") and is more foundational than others (e.g., "equity"). For instance, a lack of generosity (i.e., selfishness or self-centeredness) can breed inequity. In democratic societies, generosity comes in the form of public service as people freely give of their individual time, resources, and trust to share in governance and to promote the public good. When generosity is not present in democratic societies, the notion of public good is replaced by personal gain, and inequality flourishes. Similarly, without the lifeforce of generosity, OER run the risk of leading to futures wherein openness is mandated, co-opted, or manipulated in ways that promote greed, selfishness, inequity, and persistent ineffectiveness.

A few examples here might be instructive. In software development, openness has a relatively long history via the interconnected "free software" and "open-source software" movements and their complicated relationships with one another (Stallman, 2021). Though an in-depth exploration of these movements is beyond the scope of this chapter, the resulting software ecosystem we find ourselves in today has been shaped markedly by openness in many ways with some exciting and some troubling effects.

One problematic result of openness in our current software ecosystem is inequity based on the type or degree of resources certain companies offer. For example, recognizing that free and open can be effective hooks for attracting new users, freemium models of apps are now commonplace, wherein companies create tiered experiences and provide only the best experiences for premier, paying users. Applied to OER and education, this same mindset exists with the creation of tiered learning experiences. In these instances, some learners are given more robust educational opportunities than others in the form of inequitable access to supplements, supports, or full course materials based on their ability to pay, geographic location, or other considerations (Polonetsky & Tene, 2014). Some of these strategies have even been used in educational technology as advertising funnels or bait-and-switch scams (Hempel, 2010; Newton, 2018).

Similarly, some companies have used openness to exploit user data. As companies have recognized the benefits of data interoperability and sharing between various systems via application programming interfaces (APIs) and data repositories, they have found that providing users with inexpensive access to software allows for quick collection of valuable user data, which then can be monetized in a variety of ways. Educational technology companies are not oblivious to this, and many lucrative business models have arisen that leverage student data for profit (cf. the "Instructure Wars" [Crosslin, 2019] and proctoring software [Kimmons & Veletsianos, 2021; Morris & Stommel, 2017]). Without its ethical centre of generosity and relying instead on motivators of selfishness, greed, and control, open practices run the risk of providing even greater power to corporations, governments, institutions, and even researchers like ourselves to manipulate, control, and harvest the efforts of learners, thereby showing that openness without generosity is no virtue.

Beyond its ethical core, openness also potentially provides a way forward for our DLE that is simply better for learners in a practical sense by providing ongoing improvement of learning materials and experiences. Since they are generally digitized, OER can be easily updated and distributed to learners in a variety of formats, potentially improving accessibility, up-to-dateness, and flexibility in comparison to print-only and proprietary media. Because they can be provided without paywalls, OER can be more seamlessly embedded into learning experiences, such as by dropping content directly into learning management systems or using the internet itself as a learning platform for interconnecting diverse content and people. Because they are openly licensed, OER can be remixed for many purposes, which is immensely beneficial from a learning perspective to adapt and differentiate resources to local contexts, diverse language requirements, and other developmental or personal needs. And because authors can collect data on resource usage and adjust them with little effort, OER provide unparalleled opportunities for educators to continually improve the materials they use to meet the emergent and ongoing needs of learners. These potential benefits to teaching and learning practice have been described collectively by different names, including open educational practices (OEP; Cronin, 2017; Cronin & MacLaren, 2018; Ehlers, 2011), open pedagogy (Nascimbeni & Ehlers, 2020; Peters et al., 2012), and OER-enabled pedagogy (Wiley & Hilton, 2018). Though OER may not categorically lead to such open practices (Mason & Kimmons, 2018), they are nonetheless necessary to engage in them. As educators, we can use the benefits of OER to shape students' DLE in ways that extend beyond the classroom.

From these roots, we contend that future directions in OER design, use, and research should not focus on openness itself but on creating futures that (a) are more generous and (b) better allow for ongoing improvement (both in sustainable ways). Openness may merely be a means to achieving these aims. If we could wave a magic wand and make our DLE more open but then realized this future made learning less generous, made us less effective, or was unsustainable, then we would find ourselves in a dystopian world. Openness and OER are merely suggested vehicles for achieving these goals, and if we cannot achieve them through openness (or if there is another method that allows us to better achieve them), then openness and OER are not worth our time or effort.

For these reasons, we believe that approaching a discussion of the future of OER design, use, and research should rest on our two primary aims of openness: (a) sustainable generosity and (b) sustainable improvement. Doing so will provide us with better focus to solve the problems associated with OER and will also help to ensure that we are using these valuable technologies to shape society and educational systems in positive, rather than dystopian, ways. In the remainder of this chapter, we will limit our exploration to this first issue of sustainable generosity, but we also encourage others to help further articulate how sustainable improvement must be key to OER-connected futures (e.g., Wiley et al., 2020).

2 Sustainable Generosity.

"The only legitimate role for new media and technology in education is to increase our capacity to be generous with one another. The more open we are, the better education will be." — David Wiley

An estimated half of all agricultural produce grown in the United States each year is thrown away, making food the biggest occupant of landfills (Chandler, 2016). Yet roughly 10% of people in the United States experience food insecurity (USDOA, 2020), and 9% of people globally are undernourished (United Nations, n.d.). Why are millions of people starving while roughly one-third of U.S. foodstuffs are wasted (Chandler, 2016)? It is doubtful that U.S. farmers or supermarkets would object to their discarded produce being used to feed the hungry, so it does not seem like this problem simply stems from a moral deficiency on their part but from inefficiencies and impracticalities associated with redistribution of the unwanted produce. Though there would be no additional cost to farmers or supermarkets for the hungry to benefit from their unwanted items, the cost and logistics necessary to enable sharing of these resources is significant and might make the effective and sustainable sharing of perishable resources impossible for even the most altruistic producer.

A similar situation seems to exist in education wherein many people have valuable learning resources—such as content, expertise, and time—that they could provide to a world hungry for them, but there seems to be a disconnect between those who would give of themselves and those who could benefit from such giving. A professor who creates course materials for their students could share those materials with others outside of their class, allowing others to build upon the professor's expertise. A K-12 teacher could provide copies of lesson plans and activities to other teachers, preventing others from having to recreate the wheel in their classes. Or an adult educator could allow students from all over the world to audit their class via synchronous video. Yet, as with the farmers and supermarkets, this sharing often fails to occur simply because educators are unaware of needs, do not understand how they can help, or lack the time, skills, or resources needed to effectively share with potential students or other educators in need. Effective sharing, it turns out, can be hard work. As a result, many of us find our generous impulses and opportunities to share stymied by the cost and logistics of providing our educational sustenance to those who need it.

Generosity might mean different things to different people, but a simple definition would be that it means to willingly give of the self to benefit the other, making it antonymous to selfishness or greed. Educators as a group are likely more generous than the average person, since a desire to give, lift, and help often draws people to the profession. In K-12, for instance, 53% of teachers in the United States report using their own money to purchase food for hungry children in their classrooms (Share Our Strength, 2012), and positions at all levels within our educational systems are staffed with highly skilled professionals who have often decided to forego more lucrative careers elsewhere to give back to society or to make an impact on learners. Yet OER are a fitting example of how our generous impulses typically do not match with actual outcomes. Though the vast majority of higher education faculty believe that OER, and open textbooks specifically, are a good idea, only about 7% use textbooks that are openly licensed and only 13% use any OER at all (Seaman & Seaman, 2018). Reasons for this are manifold, including lack of time, lack of skill, lack of awareness, misalignment with performance indicators, and financial opportunity costs (Kimmons, 2016; Martin & Kimmons, 2020), but it seems that all these issues may be summarized as a failure to build systems that allow educators to be generous in a sustainable and impactful way.

We need systems in place that honour, support, and (maybe even) reward generosity. We do not need our farmers to produce more food; we need systems that make it easy for farmers to get surplus food to those who need it. Similarly, it does not seem that we need more expertise in education. Rather, we need to create systems, processes, and cultures within our educational institutions that support educators in more effectively collaborating with others, codifying their expertise into non-rivalrous learning materials, and reaching more learners. So, when it comes to future directions of OER use, design, and research, our first proposal is that educators and researchers need to be involved in creating and supporting systems and in conducting research to make generosity more sustainable within their institutions. This important work may take many forms, but we will only briefly mention three: (a) shining light on false narratives and immoral systems; (b) legitimizing, valuing, and protecting givers; and (c) exercising gratitude.

3 Shining Light on False Narratives and Immoral Systems

There are many false narratives permeating our educational systems that dissuade people from being generous, but one of the most pernicious is the gilded bogeyman of intellectual property opportunity cost. The narrative goes like this: Our knowledge and expertise are valuable; so, we should not give them away. Rather, we should keep them to ourselves until we can monetize them and make a fortune. Though the premise to this argument is true—our knowledge and expertise are valuable—the erroneous conclusion is drawn from a misunderstanding of how wealth flows in education. Of course, there are plenty of people who make an absolute financial killing in the education marketplace, such as the author of a core subject area textbook that is adopted across multiple countries or states, but this type of wealth only comes about when resources are adopted on a large scale. In contrast, much of the knowledge and expertise held by educators at all levels tends to be less scalable, such as contextual expertise of how to teach a particular subject to a particular group of students or niche expertise in an advanced, highly specialized area. Though it is still possible to monetize such expertise through the creation of educational content, doing so is much more difficult than in other creative spaces and provides less financial incentive. Royalties of nonfiction books, for instance, tend to only be 15–25%, and if the subject matter for the book is too specialized or is so generalist that it could be replaced by a variety of free sources, then the incentive for producing such content rarely outweighs the time and effort needed to do so. The result is that educators have valuable knowledge and expertise to contribute to the world that they often never get around to sharing.

Furthermore, this fixation on the financial value of knowledge and expertise also leads to a variety of morally questionable behaviours that some educators engage in. If a university professor, for example, takes the time to write a book for the market, they will often use their positions of power to influence its adoption. If they teach a class, they will require students to purchase their book and encourage their departments, libraries, bookstores, and colleagues to do the same, mandating the text for as many students as possible. This creates a situation in which student tuition and taxes fund professors to create content, and the professors then require those same students to pay again or risk failing coursework. Understandably, if a professor takes the time to write a book, then they would want it used in their class, as it would likely align best with their subject matter and teaching approach, but the moral problem here is that educators can use their positions to create pressures on financially vulnerable students, to essentially charge whatever they like for course materials, and to make a double profit from their students via tuition and materials. The advent of digital publishing has not solved this problem and may have even exacerbated it by reducing barriers to publication, removing quality assurance mechanisms, and giving professors more control via self-publication. In many higher education institutions, it is currently possible for a professor to self-publish an unvetted, low-quality book and require it in their coursework, charging whatever they like for a fee and keeping a higher percentage of profits than they would from a traditional publisher. Because professors can both publish materials in which they have a financial interest and dictate what students must purchase to pass courses, this creates a scenario ripe for exploitation, and it is no wonder that textbook prices have risen at triple the rate of inflation over the past 20 years (Perry, 2016).

Another false narrative is the belief that the cost of an educational resource is indicative of its quality. The saying "you get what you pay for" is often applied to textbooks and other materials, leading educators and curricular decision-makers to sometimes treat free resources as being of poorer educational quality than commercial products. Research on this topic has shown repeatedly that open resources yield similar, and sometimes better, educational results when compared to commercial alternatives (Hilton, 2016, 2019) and that open resources can be just as accurate and high-quality as their commercial counterparts (Giles, 2005; Greenstein & Zhu, 2018; Kimmons, 2015). And yet, the myth persists primarily because perceptions of educational resource quality in a consumer-driven society are heavily shaped by a variety of factors that may have nothing to do with a resource's impact on learning, such as its aesthetics. As an example, the most brilliant computer scientist in the world could write a comprehensive book and publish it openly on the internet, but unless they also hire a graphic designer to give it a flashy cover and a copy editor to proof the language for errors, the book may be perceived as being of lower quality than a competing book produced by a novice in the content area. Indeed, students—along with seasoned educators, designers, and researchers—"judge books by their covers." This behaviour perpetuates the false narrative that the educational quality of a resource resides in marketing appeal and leads educators to adopt form over substance: paying for publisher polish even when generous content expertise is freely available.

To combat these false narratives and the immoral systems they create, future research should explore what the actual opportunity cost is to educators for sharing knowledge to provide more transparency in their decision-making processes. Furthermore, those involved in the use and design of OER also need to be aware of these realities and recognize that creating a resource that will be perceived as being high quality by educators and students may require a diverse set of expertise and skills, such as graphic design, copy editing, search engine optimization, etc. The false narratives that prevent OER from shaping our DLE in positive ways may have come about as unintentional consequences of a historically market-driven system, but that does not mean that we are doomed to operate under these narratives. Good research and good practice can help us see that these narratives, rather than being inherently true or inevitable, may be nothing more than temporary obstacles between us and the more generous world we seek to create.

4 Legitimizing, Valuing, and Protecting Givers

The second area we must focus our efforts on in order to make generosity more sustainable is pushing our institutions to legitimize and value giving, while at the same time protecting those who are doing it. Research on OER creation among university faculty and K-12 teachers alike has shown that the primary barrier is time: educators simply do not feel that they have enough time to find, vet, or create open resources (Kimmons, 2015; Martin & Kimmons, 2020). To understand this barrier, we must recognize that educators, like other professionals, operate in institutions where their performance is evaluated, and they must devote their time to doing what their institutions signal to them is necessary for job security, promotion, etc. In the case of classroom teachers, this primarily means teaching and grading. In the case of university professors, this means a combination of research, teaching, and citizenship, though the weighting and interpretation of these categories varies by institution. Tenure-track faculty at large research universities are typically evaluated primarily on their research productivity, while those at teaching universities might need to give more attention to teaching evaluations. In every case, though, there do not seem to be institutionalized ways of valuing OER-related work. Is creating an open textbook, for instance, scholarship, teaching, or citizenship? And how would a tenure and promotion committee view such an activity? Currently, because such activities are not valued as core elements of educators' job descriptions, they are typically seen as positive supplements to one's career but are not essential for career advancement. Since expectations are so high for educators in other areas, the result is that educators simply do not feel like they have the time to engage in activities that would at best be considered a brief footnote to their overall job performance.

In response, researchers need to validate the social and teaching impacts of OER and show how such efforts stack up to more traditional approaches to scholarship, teaching, and citizenship. As an example, the Iowa Open Education Action Team recently created an information packet to help guide faculty and staff in advocating for OER-related activities "in the promotion, tenure, and faculty evaluation practices at their institutions" (Elder et al., 2021). This packet provides ideas for how different OER-related activities might be couched within the three categories valued by institutions. However, for such efforts to become fully ingrained in our institutions, we will likely need to revisit some basic assumptions that we make about scholarly impact and quality.

For example, metrics such as impact factors and acceptance rates that are traditionally used for determining scholarly merit may be less useful in a world that is increasingly digital and open. As proxies for impact and rigor, these metrics were developed with certain assumptions about the dissemination of information that may be antiquated now. For instance, journals are no longer limited in the number of articles they can publish due to paper printing and mail delivery fees, which means that a digital journal could feasibly publish every article that was submitted if each met the journal's requirements for scholarly rigor, thereby calling into question the value of acceptance rates. Digitization of scholarship has also led to growth in predatory and pay-to-publish models of dissemination, which also calls into question the relationship between article acceptance and institutional wealth or researchers' willingness to pay. Furthermore, since impact factors rely upon citation counts, those factors can be artificially inflated by some activities that may not reveal impact at all (e.g., self-citations) while simultaneously ignoring others more indicative of social impact (e.g., reading and sharing behaviours), learning (e.g., reader performance on learning checks), or quality (e.g., reader ratings of content quality). As a result, we suggest that advocacy for inclusion of OER-related activities into institutional evaluation practices should also be informed by ongoing research and conceptual work to unpack what our purported institutional values—such as impact, rigor, and quality—actually mean, as well as the exploration of how new methods of data collection and analysis might provide better proxies than pre-digital norms (e.g., West & Rich, 2012).

As we move in these directions, however, we also need to be careful to protect those engaged in the act of giving. Though digital OER are non-rivalrous by nature (i.e., they can be given without being given away or shared without precluding others from using them), their creation and ongoing development require the expenditure of professional time, which is a rivalrous resource. Any time that a professional devotes to OER is time taken away from other activities, and as educators and scholars exercise generosity via OER, there is a risk that their efforts may be exploited and drained dry. In higher education broadly, for instance, female and racially minoritized faculty may often find themselves shouldering a greater burden of mentoring, service, and committee work than their male and white peers, often being asked to sacrifice more and experiencing lower job satisfaction as a result (Allen et al., 2000; Olsen et al., 1995; Tack & Patitu, 1992). Even in cases where there is observed parity in terms of devoted time, it may be that female and racially minoritized faculty "have learned that demands for service outweigh rewards (particularly in a research institution) and self-consciously limit the time they spend on such activities—nevertheless feeling the press of extensive requests" and desire to participate (Olsen et al., 1995, p. 283). The corollary here with OER is that if OER-related work is treated simply as a worthwhile (but extra) thing to do, then those who engage in this work will potentially open themselves up to unique risks and demands, which may create a tension between the progression of OER-related work and individual career advancement.

As an anecdote, I (the first author) recently collaborated with a newly hooded PhD colleague who was seeking a faculty position. The former student expressed a desire to be involved in an open textbook project that I was working on, but though her involvement would have provided amazing benefit, I encouraged her to limit her efforts with OER for the time being and to focus her attention elsewhere (namely traditional publishing) to better safeguard her own marketability and future in academia. This advice came in response to my own experiences with OER work, which I have found to be much more feasible from positions of power (e.g., post-hire and post-tenure). The sad reality illustrated by this example is that many who have important contributions to make to the professional community via OER must often choose between doing what is generous and doing what is necessary to survive in their professional setting. If we are truly seeking to move to a future that is more open, then we need to be sure that we also are engaging in research and practices that help safeguard those who are being generous with their time and resources rather than simply expecting professionals to sacrifice their careers in the name of openness.

5 Exercising Gratitude.

"Generosity and gratitude are inseparably linked." — Judith Martin

As a final thought, we submit that because our capacity and willingness to be generous is in many ways dependent upon our perceptions of our own abilities, resources, expertise, and opportunities, it is necessary for us to reflect upon and realistically come to understand what those opportunities are. Positioning this through a more critical lens, all professionals must recognize the various privileges they enjoy by virtue of their educational attainment, institutional affiliations, expertise, skills, time, abilities, comforts, health, connections, and other benefits and opportunities available to them, or in a more colloquial or traditional sense, we simply need to recognize and be grateful for the blessings and opportunities we enjoy. Otherwise, we will quickly rationalize our way out of being generous and out of understanding the need for generosity.

There are a host of problems facing education professionals, many of whom are overworked, underappreciated, and underpaid. The persistent adjunctification of higher education (Cawley, 2020; Ovetz, 2017) and deprofessionalization of

K-12 education (Milner, 2013; Wronowski & Urick, 2021) delegitimize the professional status of educators and scholars at all levels, and we see stark inequities in how professionals are valued across disciplines and institutions (Higher Ed Jobs, 2020; Lincoln & Stanley, 2021; Pyke, 2011). These are serious, systemic problems that need to be solved. However, because it is human nature to interpret our own opportunities and deprivations in relative (rather than absolute) terms, professionals may often make determinations about their capacity to be generous based upon their relative positionality to others who are more privileged than themselves rather than from an objective realization of what they have to offer the world. The result is that many of us perhaps are not as generous as we should be and do not have the impact on the world that we could, simply because we justify withholding our generosity on the basis that such efforts are the exclusive requirement of others who are more privileged than ourselves.

Privileges and opportunities are inequitably distributed. There is no doubt about that. However, we would wager that the typical person reading this book has far more privilege, opportunity, and resources available to them than their average student (and the average citizen of the world). For instance, as a first-generation college graduate (first author) and a first-generation college student (second author), we recognize that the knowledge and skills at our disposal simply by virtue of our educational attainment provide us with unique opportunities to help others that far exceed those of our ancestors and many of the members of the communities we grew up in. Couple those privileges with technical skills, food security, professional connections, and a host of other blessings, and it becomes clear that the opportunities we enjoy—ones that most professionals commonly share—give us the potential for doing substantial amounts of good.

As stated in the previous section, we do not suggest that professionals should be generous to the point of jeopardizing their careers or opportunities for growth and advancement, but it does seem that if we want to work toward a world that is more generous via OER, then each of us must start by seriously considering how generous we should be with our time, talents, and opportunities. There is perhaps no simple principle here to follow, and how generous each of us should be will likely vary from situation to situation, but it seems safe to conclude that most of us should perhaps be more generous with these privileges than our institutions and fields encourage us to be. In talking about religiously motivated generosity, C. S. Lewis (2015) concluded the following: "I do not believe one can settle how much we ought to give. I am afraid the only safe rule is to give more than we can spare." We concur with this sentiment and suggest that if we all seek to use OER to build educational futures that are more equitable and generous, then our generosity should hurt at least a little.

6 Conclusion

The future of OER design, use, and research rests in our ability to both recognize the detriments of technocentric and consumeristic approaches to educational technology and shift course toward more generous, sustainable, and realistic views of OER. Traditionally, support for OER has lauded openness without understanding how to create a sustainable future or how to honour and protect those who give. Such oversights have caused openness to be misrepresented and misused, delaying our generous futures from coming about. If, instead, we view OER through the lens of seeking sustainable generosity and improvement, we can then retrain our understanding and reshape the future of OER within our DLE. To do so, we must interrogate our market-driven assumptions in education, legitimize giving, and practice gratitude in ways that motivate generosity. We hope that these steps can lead to lasting, impactful improvements in education as openness is no longer seen merely as a fashionable oddity or moralistic token but as a pathway that leads to the generous and more equitable futures that we desire.

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Repositories

Reflecting Open Practices on Digital Infrastructures: Functionalities and Implications of Knowledge

Johannes Hiebl, Sylvia Kullmann, Tamara Heck and Marc Rittberger

Abstract

Open practices in education focus on the actions of learners and teachers regarding openness. The sharing and collaborative creation of open educational resources is at the core of such practices. Digital infrastructures do not only provide environments for these kinds of practices but reflect ideas and implications of open practices through the functionalities they offer. Those infrastructures can be seen as drivers for enabling open practices to become default. However, a common understanding of open practices has yet to be defined. As such, designing digital infrastructures that foster open practices might be a challenge. This chapter shows the relation between open practices and digital infrastructures.

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1 Introduction

Models of open educational practices (OEP) aim at framing concepts for openness in learning and teaching. Earlier concepts of OEP have emphasized the use and creation of open learning and teaching objects, whereas more recently, researchers have investigated the meaning of openness and its diverse interpretations regarding aspects of open pedagogy (Wiley & Hilton, 2018), empowerment, inclusion, and social justice (Koseoglu et al., 2020). However, the term "*practice*" is often used without reflecting its meaning in social science practice theory and its deeper understanding (Bellinger & Mayrberger, 2019). In this chapter, we apply practice theory (Schäfer, 2016; Schatzki, 2002) to frame the concept of OEP and to explore users' intended socio-material practices as well as the media performativity of digital infrastructures that provide learning and teaching resources. Infrastructures as digital objects influence the knowledge and practices of their users. The article examines what infrastructures do in their digital materiality and how they prefigure users and their construction practices. It contributes to the current debate on open practices and the design of digital infrastructures in distributed learning ecosystems.

This chapter draws upon infrastructures that enable open practices in learning and teaching. It shows current functionalities of higher education infrastructures that provide learning and teaching objects and discusses their potential to support OEP, which we frame within the practice theory. The research question is: How might OEP be shaped by current functions in digital infrastructures for learning and teaching objects? In the following, we will introduce the concept of OEP and explain practice theory as a theoretical basis in Sect. 2. Section 3 shows the methodological approach of an assessment of infrastructure functions. Results will be discussed based on practice theory and OEP in Sect. 4, before we conclude the chapter.

2 Theoretical Background

2.1 Concepts of Open Practices in Education

OEP deal with learning and teaching practices that embrace *openness*. While the broader concept of open education challenges existing educational systems and their accessibility and participation regarding openness (Bellinger & Mayrberger, 2019), OEP seem to focus on the actions of learners and teachers, primarily the latter group. However, there is still no single concept of OEP (Bellinger & Mayrberger, 2019).

A main aspect of OEP is the open sharing of educational content (Koseoglu et al., 2020), mostly visible in the concept of open educational resources (OER). Diverse definitions exist, and, generally, the idea of OER as "teaching, learning or research materials that are in the public domain or released with intellectual property licences that facilitate the free usage, adaptation and distribution of resources.".[1] OER practices are often described with the 5 Rs (Wiley, 2014). The 5 Rs demand the right for users to retain, reuse, revise, remix, and redistribute open learning materials. They also represent the ideal of an OER lifecycle (Beaven, 2018). To fulfil those requirements, the core of OER are open licences like Creative Commons,[2] granting appropriate rights to users to enable this lifecycle. Creation and usage of OER differ and depend on the material type and educational context. Guidelines like the OER gold standard by Fabri et al. (2020) describe best practices for different types of OER, such as slides, videos, and blogs. The guidelines aim at creating OER with openness in terms of accessible reusing and remixing activities which requires legal and technical prerequisites. However, studies have shown that barriers remain to using and sharing OER and there is a need to raise awareness of OER and knowledge of OER practices (Cardoso et al., 2019). If the sharing of OER takes place publicly, it happens in open repositories (Beaven, 2018; Cardoso et al., 2019). Otherwise, activities of sharing without licence declaration can be observed in communities of teachers and students (Baas et al., 2019; Beaven, 2018). Beaven (2018) refers to this as "dark reuse".

Concepts of OEP broaden the idea of OER, as (re)using and sharing learning resources alone does not contribute to openness in education. Koseoglu et al., (2020, p. 153) consider "that a core driver of a wide range of such open(ing) practices has been to improve access, equity, and inclusion, both in and through education." A more concrete definition of what *open (educational) practices* means seems complex. Cronin (2017, p. 4) draws upon different descriptions in the literature and defines OEP as: "collaborative practices that include the creation, use, and reuse of OER, as well as pedagogical practices employing participatory technologies and social networks for interaction, peer-learning, knowledge creation, and empowerment of learners."

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[1] https://en.unesco.org/themes/building-knowledge-societies/oer.

[2] https://creativecommons.org/.

Baran and AlZoubi (2020) define "open pedagogy practice as a dimension of OEP that includes teaching and learning practices while engaging in renewable assignments." They report on practices investigated in a study on OEP and student participation. Pedagogical practices observed include peer feedback and community engagement regarding open access knowledge and awareness, as well as student agency, for instance through contribution.

Koseoglu and Bozkurt (2018) emphasize the *practices* in OEP, i.e. the processes in education as opposed to any outcomes like OER: "[W]e define OEP ideally as a broad range of practices that are informed by open education initiatives and movements and that embody the values and visions of openness" (Koseoglu & Bozkurt, 2018, p. 455). Practices, thus, include open approaches in education, which might be influenced by factors of culture, pedagogy, technology, legal issues, financing, and labour (Hodgkinson-Williams, 2014; Koseoglu & Bozkurt, 2018). This description of OEP covers the concepts for investigating open practices in education as an umbrella term. By emphasizing external factors, it considers OEP as a concept within an environment that needs to be drawn upon to understand OEP and their impact on education. Within practice theory, we stress this deeper relationship of practices and the environment.

2.2 Practice Theory as a Basis for Studying OEP

Practice theory incorporates interpretative and structuralist culture theory (Reckwitz, 2002). It draws upon two major questions: (1) Which options for action do actors have within cultural orders? (2) How do cultural orders develop by reproduction and transformation? (Schäfer, 2016, p. 10). Practice theory does not view actions as isolated, but as connected. Practices are collections of actions and sets of rules and resources. The "identity" of a practice depends on its social context and its relation to other practices, including past ones (Schäfer, 2016, p. 11). The core of practice theories focus on an identification of differences between social practices (Schäfer, 2016, p. 12). Praxeologically, social order is understood as a temporal process for which a course has to be analysed (Schäfer, 2016, p. 13). Practices in their physicality, in their understanding of practice and social situation, and the competent execution of situationally adequate practices are attributed to an incorporated tacit knowledge (Schäfer, 2016, p. 13). Practice theories emphasize the materiality of the social, in the relevance and usage of artefacts, technologies, spaces, media, and images (Knorr Cetina, 2001; Schäfer, 2016, pp. 13–14). Practice theories acknowledge that there is a continuing generation of practices whose forms are changing historically and locally, and, therefore, the “essence” of individuality and society is changing as well (Schäfer, 2016, pp. 12–13).

If we take OEP as a “broad range of practices that are informed by open education initiatives and movements” (Koseoglu & Bozkurt, 2018, p. 455), practice theory spans three relevant dimensions of entangled socio-material practices that can be investigated, i.e., transformation, reproduction, and action capabilities (compare to Schäfer, 2016).

Transformation considers intended achievements of OEP in terms of their political framing, as is visible in OER definitions and policies. Reproduction considers intended achievements of OEP provided in digital infrastructures that offer OER as a kind of output of practices. Infrastructures do not only provide OER reuse and sharing and other participatory OEP, such as student engagement. They also reflect ideas of OEP and their application in digital environments. Action capabilities consider how epistemic cultures affect the usage of infrastructures to *do* OEP. Action capabilities are affected by transformation and reproduction instances. In this sense, practice theory does not ask for a concrete definition of OEP but focuses on practices that are being shaped within those dimensions. The theory emphasizes that the dimensions are interwoven and may even be interdependent.

According to the literature, the understanding of OEP has evolved and newer sources draw upon aspects similar to the understanding in practice theory. As Koseoglu et al., (2020, p. 153) state, “First of all, such practices [OEP] have historicity. They are situated within socio-economic, cultural, political, and technological contexts, and shaped by worldviews, participants, and available resources (human and non-human)”. The authors further state that those practices “should be better understood as a multidimensional and interdisciplinary construct that encompasses a diverse range of open(ing) practices” (Koseoglu et al., 2020, p. 153). Thus, practice theory and newer approaches to OEP consider practices within the context of other influencing factors. Practice theory stresses the inter-relational dependencies between practices, actors, and contexts: practices are shaped in contexts, and they shape the context itself. Furthermore, Koseoglu et al. (2020) see the conceptual approach of to OEP closely related to a discussion on openness and digitization. Whereas the latter might be concretely described as a technical component in digital services and systems, understandings of openness are multiple and provisional (Koseoglu et al., 2020). An assessment of all inter-relational dependencies and contexts relevant for OEP would go beyond the constraints of this chapter. In the following, we approach OEP through existing digital infrastructures and their functions and how they impact OEP regarding transformation, reproduction, and actions capabilities.

Still, the term ‘practice’ bears one limitation regarding the investigation of OEP in infrastructures. Practices must always be seen as physical, bodily practices because bodies are not extrasocial. Bodies are products and sources of the social and point to subtle differences (Bourdieu) and disciplining orders (Foucault) of the social. Bodies affect the course of practices, take part in practices, and are shaped by practices – they incorporate sociality. Cultivated practices can be questioned by new technologies and business models (Kuhlen, 2012). As such, infrastructures like OER repositories play a central role in supporting OEP. They provide learning and teaching resources and their functions set the potentials and barriers of user behaviour to practice openness in those infrastructures. Infrastructures are part of an ecosystem for learning and teaching that shall enable an unfolding of OEP potentials. To fulfil this goal, functions of infrastructures need to map onto intended open practices. With the rise of OER initiatives and funding opportunities to establish OEP, new digital infrastructures, specifically OER repositories, are being developed with the main goal to provide OER and make them searchable and shareable.

To create OER, various practices are needed, such as generating texts and graphics, creating video and audio material, searching for and combining material, licensing, but also providing information on created OER and their practice. These practices are entangled with their material infrastructure. The social context of OER becomes apparent in the technical framing through infrastructures and in the political framing through policies and guidelines (Hiebl, 2021). In this regard, it must be considered that the observation of OER is always an observation from the perspective of a final product with high demands. Thus, educational resources in their construction practices can only retrospectively be declared as OER. Digital OER are, in several ways, “relationally and ecologically” entangled with infrastructures (Star, 1999) and “intra-actively” entangled with their users (Barad, 2010). As participants order objects such as OER, they are ordered by them, namely, by their different technical and media-related performances and (un-)availability in archives, their edition at virtual workplaces, and their usage in virtual education rooms.

In order to leverage the potentials of digitisation for university education, a distributed learning ecosystem across universities is required that provides digital educational resources for shared use (cf. Kerres & Heinen, 2015). For the university sector, a feasibility study run on behalf of the German Federal Ministry of Education and Research (BMBF) by Deutscher Bildungsserver (2016) showed, regarding the infrastructure of OER, that an increasing amount of digital content exists on learning platforms and that technologies are available to provide this via repositories. A solution is necessary that is based on a networked, federated infrastructure of local repositories (cf. Heinen et al., 2016) and that enables the targeted use of the opportunities of OER. Given their definition as teaching, learning, and research materials, OER already are ubiquitous at universities, in open access servers for publications and research data or in learning management systems. However, this openly accessible material has not been created specifically for educational purposes. To provide educational material, i.e., OER embracing all five user rights (Wiley, 2014), and a pedagogical concept, higher education institutions have started to provide either new infrastructures (like OER repositories) or new functions within existing infrastructures (like OER search within learning management systems).

To study how using and sharing of OER might be shaped as reproduction of intended achievements of OEP within these digital infrastructures, we investigate higher education services that provide learning and teaching material. In the following, we introduce our sample of OER infrastructures and our set of analytic categories, before we discuss the results regarding potentially shaped practices.

2.3 OER-Providing Digital Infrastructures

In general, there are three types of OER-providing services: services that house content primarily on site and follow a centralised model – we refer to them as repositories –, services that provide links to learning objects housed elsewhere – similar to referatories (Heinen et al., 2016) –, and hybrids that provide both. Not all OER-providing digital infrastructures and services are referred to as such explicitly. As said above, OER are often provided via existing infrastructures like learning management systems or open access servers. The latter have often been designed for open access research publications and now also allow storage of OER. The framing of learning objects as OER might complicate a comprehensive understanding of OER infrastructures and their functions. If there is no common understanding, intended users might find it harder to search and find appropriate OER. Findability is a crucial quality criterion for open infrastructure and resources (compare DINI certificate[3] and FAIR principles[4]). The lack of a common understanding makes it harder for users to adopt and embrace further OEP, like creating and reusing OER, or to engage in more collaboration and participa-

[3] https://doi.org/10.18452/21759.

[4] https://doi.org/10.1038/sdata.2016.18.

tion (Baran & AlZoubi, 2020; Heck et al., 2020). In summary, it is hard to gain an overview of the landscape of OER-providing digital infrastructures and services in higher education. To provide an overview and help users identify relevant OER infrastructures, an institutionalized overview by universities and ministries of culture would be desirable.

3 Method

3.1 Sample of Assessed Infrastructures

We searched for digital infrastructures from November 2020 until January 2021. The sample we analyse here is a sub-sample we searched for and created in a university course. To identify services that provide OER, websites of 118 state-operated, German-language universities in Germany, Austria, and Switzerland[5] were searched with the German terms for "open educational resources", "OER", "repository", "learning material", and "teaching material", using the websites' search slots. From each search, we chose the first ten results that led to a page containing learning, teaching, or research material. Eventually, we retrieved 164 potentially relevant links that led to learning, teaching, and research material. The links were first sorted into four groups, and the two most relevant groups A and B were considered for analysis (Fig. 1).

3.2 Limitations

Our list of 164 links is, obviously, not exhaustive. We only searched on websites of state-operated universities in three countries, universities of applied sciences, and private as well as confessional universities were excluded. The selected search terms were intended to cover very general searches lay users might

[5] The list of universities compiled on: https://de.wikipedia.org/wiki/Liste_der_Hochschulen_in_Deutschland; https://de.wikipedia.org/wiki/Liste_der_Universit%C3%A4ten_in_%C3%96sterreich; https://de.wikipedia.org/wiki/Liste_der_Hochschulen_in_der_Schweiz.

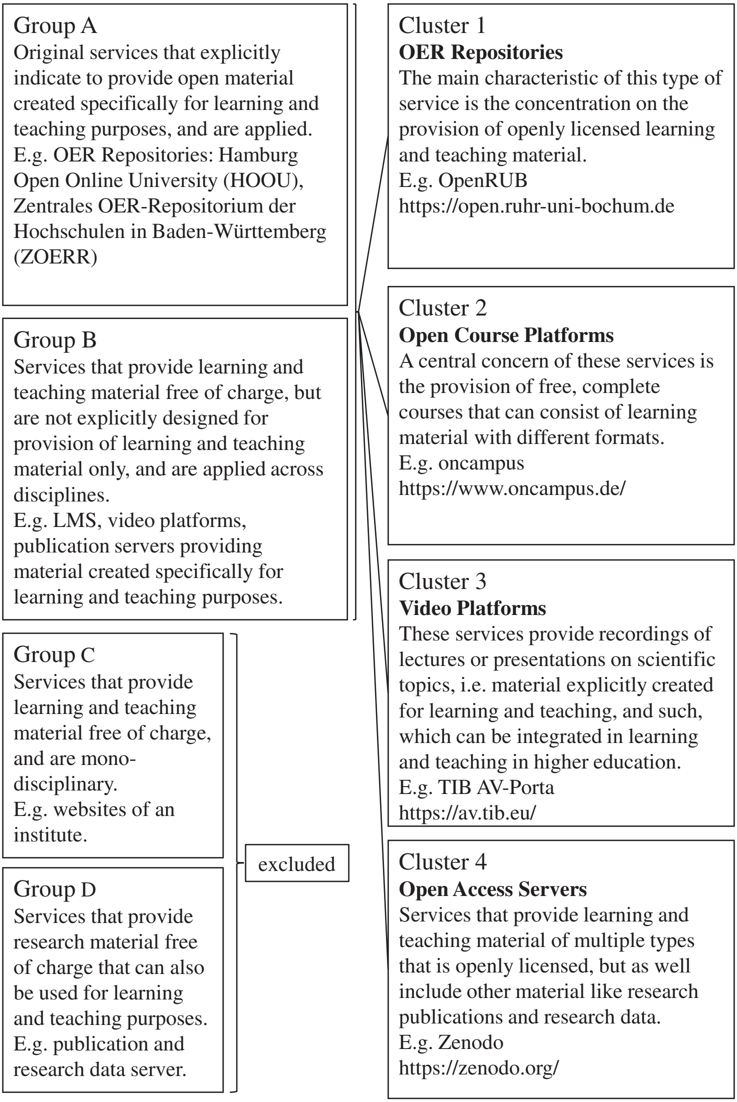

Fig. 1 Population clustering

perform. We did not run a discipline-specific search, which would possibly have led to more results. We deliberately excluded all search results that came after the first ten to keep the amount of data reasonably manageable. Moreover, it is unclear to what extent the used type of browser and the search engine of the respective university websites influenced the search results. Regardless of these limitations, we consider the identified results adequate for identifying relevant OER infrastructures as we found a sufficient number of repositories of OER and services called differently but providing accessible educational resources, i.e. our list is not limited to services explicitly labelled OER repositories.

3.3 Development of Assessed Categories

We examined the functions via document analysis (Flick, 2018) by means of qualitative content analysis (Mayring, 2014). We developed deductive categories on the basis of the existing research about OER repositories (Sampson et al., 2013; Santos-Hermosa et al., 2017; Zervas et al., 2014), i.e., 15 categories for general description of the services and 32 categories and 67 sub-categories for description of the functions. During the analysis, we included further inductive categories that describe relevant functions. This led ultimately to 19 categories for general description, and 46 categories and 184 sub-categories for description of the functions. In the following, we focus on the 46 categories, which we merged into 16 categories and, in turn, assigned to the four core functions relevant for OEP. Each of these 16 categories asks if the underlying function enables socio-material practices.[6]

4 Results and Discussion

Our analysis and results section consists of two parts. First, we group the retrieved infrastructures (164 links) into four groups showing different types of digital infrastructures (Sect. 4.1). We then analyse the functions of infrastructures belonging to the two most relevant groups more in-depth (Sect. 4.2). The impact of those functions on OEP is discussed in Sect. 4.3.

[6] The full list of services and categories is available at OSF: https://osf.io/btdcw/?view_only=cb236ff464244230be9cb14eb9702602.

4.1 Types of Digital Infrastructures

By grouping the infrastructures (Fig. 1), we aim to distinguish two major differences that we see as relevant for intended users regarding OEP: the purpose of the service and the provision of material. Group A services, designed to provide OER and explicitly stating their purpose, e.g., through their names, allow users to identify the purpose of the service and provided resources. Furthermore, services designed explicitly for OER allow easy implementation of functions necessary to make OEP visible (Heck et al., 2020). Group B services provide learning and teaching materials like OER, but also other material that is accessible free of charge. The services' functions might be suitable for OEP, but they do not focus on these purposes. For example, open access servers focus on searching and finding material and not on any collaborative aspects of OEP like editing and remixing OER. Learning management systems might have a higher potential regarding their functions. Still, our analysis shows (see 4.2) that current services from group A often lack relevant functions be necessary to foster the concept of OEP.

In the analysis, we concentrated on the nine services allocated to group A and the 28 services in group B to focus on infrastructures that offer materials created solely for teaching purposes and on multidisciplinary services that might enable participation beyond disciplinary and institutional boundaries. Services in group C did not offer multidisciplinary materials and were excluded for analysis. In services in group D, we did not find any labelled educational material.

4.2 Functions of OER Infrastructures

We grouped the 37 infrastructures from groups A and B in four main clusters considering the provided content. Cluster 1: Five infrastructures are explicit original OER services. The main characteristic of these services is the focus on the provision of OER. Cluster 2: Nine services are open course platforms. These services focus on the provision of free, complete courses that consist of learning material with different formats. Cluster 3: Seven services are video platforms that contain only audio-visual material. These services provide recordings of lectures or presentations on scientific topics, i.e., material explicitly created for learning and teaching, and such that can be used for learning and teaching. Cluster 4: Sixteen of the services are classified as open access servers that provide learning and teaching materials of multiple types that are openly licensed, but also include other material, such as research publications and research data. Table 1[7] shows a summarised version of 16 (merged) categories relevant for OEP, i.e., functional items that allow and might shape social practices related to OEP, and their occurrence in the 37 infrastructures. The categories are aligned to four core functions explained next.

4.3 Impact on Practices

Atenas and Havemann (2014) suggest the key themes search, share, reuse, and collaborate as leading concepts in the development of services for learning resources. Our analysis shows that the services mainly cover four core functions: 1) search, 2) organise, 3) help (manual function), and 4) delivery. Functions fostering collaboration, such as social tagging, commenting, and user communities play a minor role. Next, we discuss these functions on the OEP concept in relation to performed socio-material practices.

4.3.1 Search

The search function enables reproduction of findable and accessible learning and teaching materials by bodily search practices, interwoven with the user interface. Figure 2 shows the search environment of the TIB AV-Portal for scientific videos as an example. The core function "*search*" enables socio-material practices within a web application most obviously. Searching, or rather the service of finding, is performed in interaction with the users as the searchers. In our material, we discovered three search categories. First, the category of *advanced search* describes whether the search function of the web application offers two or more fields for a search query, additional metadata fields to be searched in, and filters to refine the search. Second, the category *save search query* examines if users can save their search queries within the web application. Saved search queries offer a form of memory function. This can reproduce search practices without necessarily memorising used search terms or filters. Third, the category of *sorting of results and result page design* describes options for sorting and listing search results and granular material, for example, by alphabetical order of titles, relevance, date of last change, date of generation, institutional origin, author, publisher, and so on. Also, users' switching between result page designs, e.g., from tiles to lists, is considered

[7] Full code table online: https://osf.io/btdcw/?view_only=cb236ff464244230be9cb14eb9702602.

Table 1 OER practice enabling categories

			Cluster			
			1	2	3	4
Core function	**(Merged) category**	**Code**	n = 5	n = 9	n = 7	n = 16
Search	Advanced search	sf01bi	5	7	7	15
Search	Save search query	sf07bi	2	0	1	2
Search	Sorting of results and result page look	rb03sf0506bi	3	2	5	14
Organise	Save watch lists/collections/search result	rb0102sf08	2	5	2	4
Organise	Search function and folders for own material	uf0412	2	0	2	2
Organise	View metadata/material details	md05	5	1	7	16
Organise	Download metadata/citation	md0607	1	0	2	9
Help (manual function)	Manual/help	um010203040609	5	5	5	14
Delivery	Add new (and supplementary) material	up010809	4	3	3	11
Delivery	Add metadata	up0305	4	2	5	13
Delivery	Default licences	up04	3	1	3	12
Delivery	Automatic reminder and restrictions	um05up06	0		0	2
Other functionalities	Social interactions	rb04uf0910	3	9	5	11
Other functionalities	Recommendations	qa01	1	1	5	0
Other functionalities	Quantifying	qa02sf0304	4	5	7	16
Other functionalities	Editing options	uf03bi	0	2	1	2

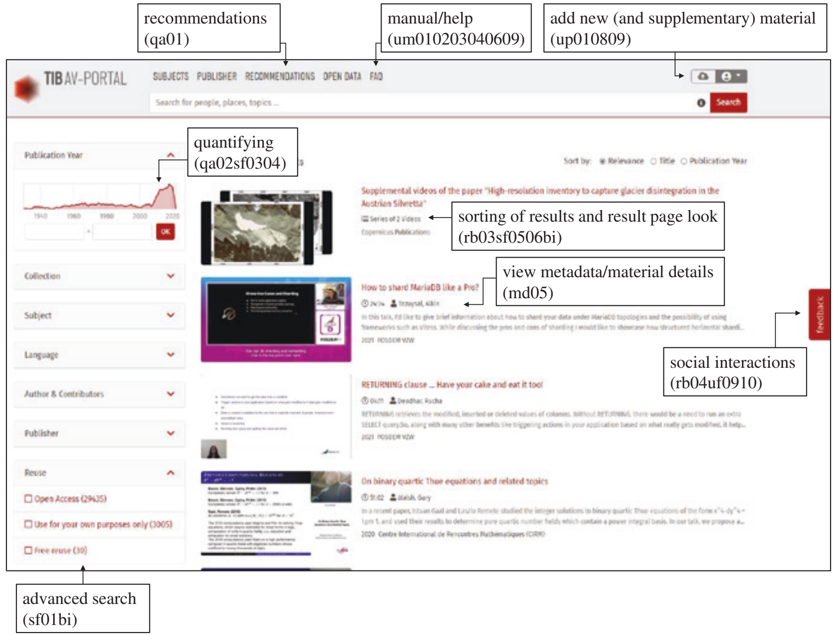

Fig. 2 Search environment of TIB AV-Portal

to have an impact on sorting practices. Sorting practices can influence the selection of material in terms of displaying material on top of a list or by giving detailed (metadata) information about the material via lists and tiles.

4.3.2 Organise

The organise function enables users to practice cultures of collaboration and sorting materials, which can be understood as epistemic cultures (Knorr Cetina, 1999). The core function "*organise*" mostly focuses on practices of arranging learning and teaching materials within the web application. For example, for subsequently saving and storing a resource, organisation practices such as creations of lists, user collections, or saving the search query become relevant. In our empirical material, we discovered four categories of organizing. First, the category *save watch lists/collections/search results* examines the options to add material to watch lists or to create collections from material (uploads or references) by users, either in private lists/collections or in shared lists/collections. These are practices of sorting and listing to organise material and to make it obtainable for prospective use.

Second, the category *search function and folders for one's own material* describes whether the web application offers a folder view (and creation) to manage user-created material. Additionally, we looked for an internal search function for each user's own material. The creation of folders is a sorting practice in its own right. The users prepare their folders with a specific idea of what they would like to sort with specific categories and attributes. Third, the category *view metadata/material details* examines whether users can see (educational) metadata of single resources. Users' understanding of educational metadata influences the selection practices for resources. This practice can also be seen as part of the search practices. The category "*download metadata/citation*" describes the ability to download and store metadata (e.g., XML) and/or citation data (e.g., BIBTEX, RIS, TEXT). In contrast to our other categories, this category does not focus on functions within the web application. Nevertheless, we consider citation of OER an underestimated factor of OER reuse. Availability of information about correct citation in a familiar format could facilitate OER citation practices and OER use and influence the selection of material. This leads us to our next core function, the help (manual) function.

4.3.3 Help

The core function *help (manual function)* is researched through the category *manual/help*. It is part of manual and help pages and "how to"-descriptions for the service itself, its technical features, and legal conditions, but also regarding explaining OER and licence types, OER authoring, and editing options. The help function supports practices of self-information and self-socialisation for becoming a competent user of the service. Users need to be educated to become competent users, which is made possible by help functions such as information pages that describe how to use the online service. In this regard, questions about copyright issues need to be answered, too. Legal questions play a crucial part in providing and enabling the release of open-licence learning and teaching materials. Moreover, manuals describe how to release OER. This can either be done by the user or by editorial assistance of the service.

4.3.4 Delivery

The delivery function prefigures user practices performatively, e.g., via determined licence models. Transformation of practices and the political framing of OER are implemented in OER infrastructures. The core function *delivery* mostly concerns uploading of material. Of course, there are other publication practices via libraries or editing boards, which we do not mention because we focus on user interaction within the web applications. In the delivery function, the social context of OER becomes apparent in the technical framing through infrastructures and in the political framing through policies and guidelines. In our empirical material, we discovered four categories of delivery. First, the category *add new (and supplementary) material* describes if users can directly add new or supplementary material to the service via upload or reference. This category is essential as it allows for sharing and distributing OER, two actvities that are as relevant for the concept of OER as (re)using objects. However, uploading is a practice full of prerequisites. A competent user needs to understand the idea of OER and open licences. Users need to know how to attribute and reference material. This can be achieved by the help (manual function). Uploading is also predetermined by the web application itself and its interface. Figures 3 and 4 show the upload environment of the TIB AV-Portal for scientific videos as an example. Second, the category *add metadata* examines if users can describe material via metadata and (prescribed) terms. These metadata fields could be (co-)authors, (sub-)titles, formats (e.g., pdf, docx, txt), access rights/licence, size, class of material (learning, teaching, research), semester, granularity (e.g., worksheet, single lesson, course, textbook), competencies, and so on. The terms could be uniquely identified or entered as free-format text. The category examines uploading options of metadata when adding new material and editing options of metadata for existing material. Describing practices are deeply interwoven with the material itself but must be considered as practices in their own right. They gain value through their necessity for the search function. The use of metadata standards by infrastructures plays a major role here (Vagliano et al., 2020). Third, the category "*default licences*" examines the provided licence models (e.g., CC 0, CC BY, CC BY-SA) that can be specified via the upload function. It is related to, but more restrictive than naming licences (freely) by metadata. This prefigures possible practices of choice. Fourth, the merged category *automatic reminder and restrictions* describes technical reminders (e.g., pop-ups) when uploading or downloading material to correctly use OER material in terms of reuse and reference material. It also asks whether the web application enforces uploading material in open formats. Remixing and revising OER is easier when the resource is shared in an open format, and standards recommend this (Fabri et al., 2020). This, again, would require teachers to change tools and practices, which they might see as an obstacle as the way they are currently creating slides is working very well for them (Heller et al., 2020). Infrastructures showing OER formats or offering filters to searchers allow easy assessment of practically revised or remixed resources. However, in our analysis, none of the web applications had implemented measures to support the usage of open formats.

Fig. 3 Upload environment in the TIB AV-Portal (metadata)

4.3.5 Other Functionalities

Other functionalities that enable and influence practices are the interaction and information function and the editing section. Interaction and information is about social interactions, quantifying, and recommendations, as well as *editing options* as a functionality of its own.

The merged category *social interactions* examines if users are able to interact with each other within the web application: via a forum, wiki, blogs, via chat/messenger, via establishing groups/networks within the service, via rating/commenting on individual material, or via social tagging (e.g., user X can see user Y's material and keywords saved in user Y's user environment). It also examines whether users can share material with other users within the service

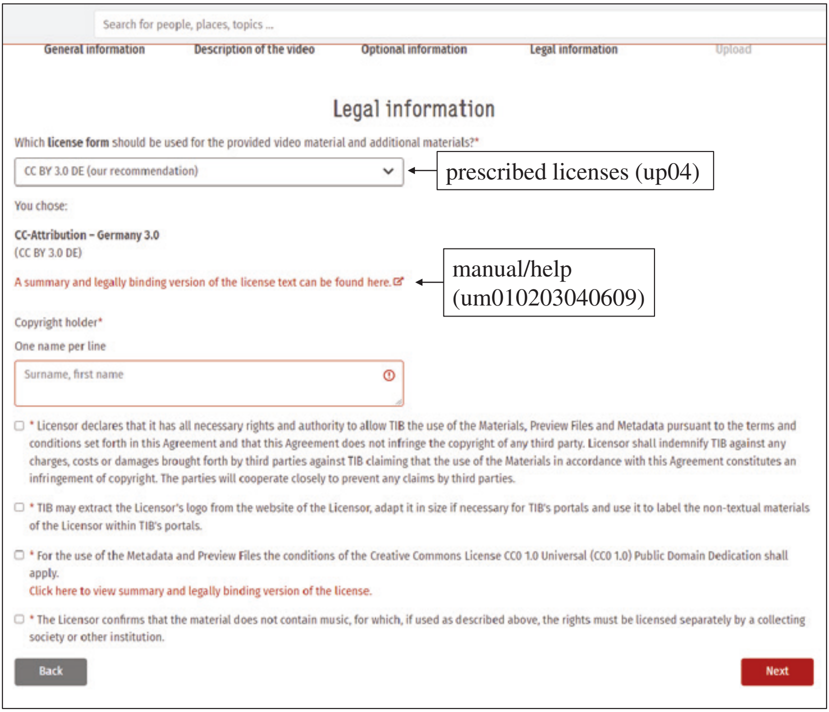

Fig. 4 Upload environment in the TIB AV-Portal (help and licences)

(privately or in public) and interactions via newsletter and via RSS feed. The category describes options (on the search and/or results page) for sending resource requests, suggestions, and problems to a team of editors and for sending requests, feedback, and problems with the web application to service staff. These interaction practices are closely related to collaborative practices of learning and teaching, community building, social visibility, and technical service. However, we must bear in mind that these practices can be enabled within a web application, but many of them can also be done outside the service and be part of everyday communication practices.

The category *recommendations* describes whether the web application gives recommendations (recommender system) for material, either based on user profiles or by editorial staff. Recommendations can influence the selection of material by making material visible users would not consider selecting by themselves.

The category *quantifying* examines if the web application gives any kind of metrics or statistics (e.g., number of users that opened a single object, number of downloads of a single object, number of citations of a single object, number of participants). It also examines if the user obtains information on the number of search results by display or the number of search results per filter and/or subcategory. Quantifying in terms of metrics or statistics can influence the selection practices of material. Quantified information about the number of users, number of downloads, number of search results, and so on can also be considered a kind of recommendation.

The category *editing options* asks whether the service has an editor (text, graphic, audio, video) on the web page to edit objects directly and save changes. This is a core function of constructing learning and teaching materials. However, it is usually not available in web applications for finding and storing learning and teaching objects. It is a function of highly specialized software. Users mostly have to be trained to use this software properly. Nevertheless, for OER and their implied promises, editing options could enable many practices within the web applications and foster collaborative working, using open licences and open formats.

The analysis of the infrastructure functions does not show a clear tendency towards certain functions in any of the four clusters (explicit OER, video, course, mixed). Relevant search functions are provided by almost all services. The availability of further functions varies in our analysed infrastructures. A positive development is that many universities offer their own digital infrastructures to share learning and teaching objects. Affiliated users can decide for a local service that is connected to other institutional digital services. However, so far, these infrastructures are not connected within a common learning ecosystem. One reason might be a high level of independence and autonomy of higher education institutions (see chapter Otto and Kerres); another the long-standing systems that were not designed to be part of a distributed learning ecosystem.

Moreover, as our analysis shows, the diversity of such infrastructures regarding functionality and accessibility might be a barrier to a broad adaptation of the services and approaching OEP, especially in higher education, where researchers and educators often change their affiliation. Distributed, non-connected infrastructures hinder more effective communication and collaboration on OEP within related disciplines and beyond institutions in higher education, a benefit researchers might aim for (Kullmann et al., 2021). We can see that higher education has started establishing digital infrastructures to foster sharing and finding OER, but core functions for OEP are missing and infrastructures are not connected within a distributed learning ecosystem.

5 Conclusion

Considering practice theory, we aimed to frame OEP regarding capabilities of socio-material practices in current OER infrastructures in higher education. We explored how OEP can be shaped by current functions in digital infrastructures for learning and teaching objects. Transformation and the political framing of OER are implemented in OER infrastructures. In a performative way, infrastructures prefigure user practices especially through the delivery function, where specific licence models are determined. The political framing and the idea of openness are inscribed in the delivery function. The search function is part of reproduction via infrastructures. Bodily search practices are interwoven with the user interface and the findable and accessible learning and teaching materials. Action capabilities are affected by transformation and reproduction instances. Cultures of collaboration and cultures of sorting material can be understood as epistemic cultures. The organise function allows users to practice cultures of collaboration and sorting material. The help function enables using the other functionalities by self-information and self-socialisation to become a competent user of the service.

Our research shows that current infrastructures can be a basis for OEP, however, services and functions are diverse and infrastructures are still not connected. An open distributed learning ecosystem for higher education in Germany has still to be established, although there are promising projects like ZOERR and OER-späti that contribute to a growing ecosystem. Besides this framing and relevant discussions on OER infrastructure developments, research needs to investigate open educational practices in learning and teaching contexts and their impact on and benefits for teachers (Albion et al., 2017) and students (Baran & AlZoubi, 2020; Wiley & Hilton, 2018).

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The Technical Specifications and Requirements for Connecting OER Repositories Using the LOM Standard

Mohammad Abdel-Qader, Ahmed Saleh and Klaus Tochtermann

Abstract

One of the goals of creating Open Educational Resources (OER) is to increase their accessibility for more learners. Connecting the different repositories that provide that these OER use one standard can help achieve that goal. In this chapter, we give detailed specifications and requirements for connecting different OER repositories using the Learning Object Metadata (LOM) standard from a technical point of view. We define the used technical terms and show how the process is working at the back end. More specifically, for each stage of connecting repositories, starting from harvesting the metadata from those repositories to storing the processed data in files ready to be used in the front end, we describe the functional requirements, what technologies are needed, and how the process works. In this chapter, we will describe the process of connecting the OER repositories using the LOM standard from start to end as simply as possible. The idea is to allow non-technical staff to replicate such a process, or maybe some stages of it. Afterwards, we give some examples of the tools that may help in the process of harvesting data from the web. Some

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of these tools are visual and do not require any programming skills. Finally, we briefly describe the EduArc project, which connects OER repositories using the LOM standard.

1 Introduction

There are many providers of educational resources, such as educational institutes and universities. One form of educational resource is the Open Educational Resources (OER). OER can be defined as resources used for learning and published under the license of open access (Hylén, 2006), which can be provided in many formats, such as videos, slides, etc. The metadata of the OER is the data that describes the OER and is stored in a database management system or index.

The OER providers have many options to model their metadata. One option is to use the existing standards such as the Learning Object Metadata (LOM) standard (IEEE 2002), the Learning Resource Metadata Initiative (LRMI),[1] and the Metadata Object Description Schema (MODS).[2] The second option is not to use any of the existing standards and to model their own style.

Connecting the OER repositories using one standard can increase the accessibility of these OER resources. Furthermore, it can achieve one of the principles of FAIR as referenced by Wilkinson (Wilkinson et al., 2016), which is Interoperability. In general, FAIR principles represent data publishers' guidelines to providing their data using digital publishing with maximum possible added value. The idea of the interoperability principle is that the data must work in conjunction with other data and applications. Additionally, using one modeling standard to represent the OER will facilitate sharing the metadata among the OER providers.

In order to connect these different OER repositories using one standard, we follow three steps. Figure 1 shows these stages on a conceptual level. More details will follow below. The first stage shown in Fig. 1 is collecting or extracting data from the different OER repositories. This process is called harvesting. Afterwards, the harvested data will go into different processing steps. These steps include cleaning the harvested data and assigning to the data into the proper field of the LOM standard. The final stage is storing the resulting data. The processed

[1] https://www.dublincore.org/specifications/lrmi/1.1/, last accessed: October 10, 2021.

[2] https://www.loc.gov/standards/mods/, last accessed: October 10, 2021.

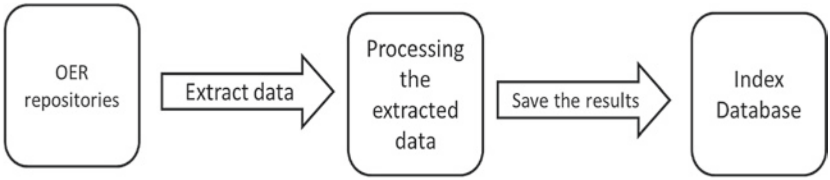

Fig. 1 The different stages for connecting OER repositories using known standards

data will be in the form of structured data, which can be stored in a database or in an index.

The detailed process is shown in Fig. 2. The process shows three scenarios (Abdel-Qader et al., 2021). The first scenario is when the OER repositories use the LOM standard to model their metadata. The scenario shows that when the data is harvested, it is immediately ready to be stored. This scenario is the best-case scenario as it follows all four FAIR principles: Findability, Accessibility, Interoperability, and the Reuse of digital resources. All you need is to obtain the data and then store it.

The second scenario shows that when the OER providers use any other standard but LOM to represent their metadata, a mapper must map the harvested data into the

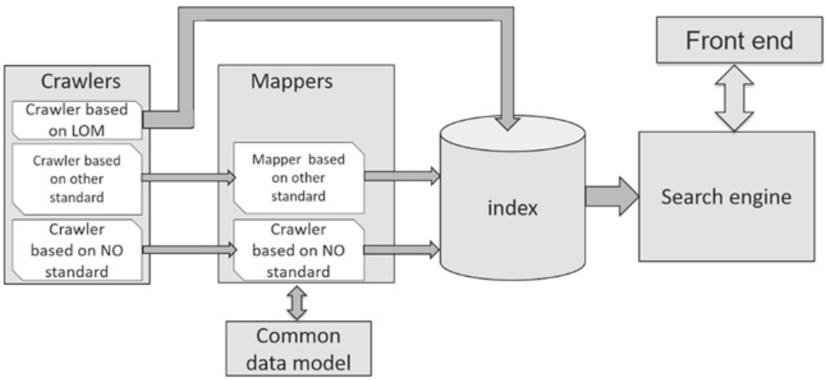

Fig. 2 The scenarios of harvesting and mapping the OER metadata that are modelled using the LOM standard, other standards, or no standard, starting from harvesting the metadata to storing the results and presenting them on the front end

LOM standard. In this case, we need a mapper for each standard. Then, each repository needs a dedicated mapper. The last scenario **occurs** when none of the existing standards is used. In that case, more work is needed from the developers. This last scenario would mean not applying FAIR principles since not using a standard will not achieve the accessibility, interoperability, and reusability principles.

When the data is mapped, it is ready to be stored in an index. Afterwards, a search engine can be developed to interact with the index. This will allow searching for open educational resources. A front end will facilitate that interaction with the index.

The remainder of this chapter is structured as follows. In Sect. 2, we describe the LOM standard and its main features and elements. The web harvesting process and the harvesting policies are described in Sect. 3. In Sect. 4, we show the process of metadata mapping. Sections 5 and 6 describe the results and how to store them. A brief description of some of the harvesting tools is given in Sect. 7. Finally, an example of one of the projects that connect OER using the LOM standard is shown in Sect. 8 before we summarize the main points.

2 The LOM Standard

The LOM standard (IEEE, 2002) is a data model to represent the metadata of educational resources, such as video lectures, presentation slides, or other formats. The LOM standard consists of a set of fields that specifies the format in which the metadata of the educational resources is stored. It controls the stored metadata to make sure that all the data follows the same rules and formats. The metadata is stored in a digital format. This allows the sharing and reusability of the metadata among different educational platforms.

The LOM standard consists of 15 main elements. These elements represent the structure of the metadata of the educational resources. Most of these 15 elements contain more detailed sub-elements in order to add more levels of information to describe the educational resources. A list of theses 15 elements is shown in Table 1.

As an example of these 15 elements, the LOM standard has the element “general”, which gives the most general information on the educational resource, such as the title, language, and keywords. Another example is the “technical” element. This element describes the technical properties and requirements of the learning resource. It consists of five sub-elements, such as the format, size, and duration information.

Table 1 The main 15 elements of the LOM standard

Metadata	Technical	Description
Lom	Educational	Datatime
General	Rights	Entry
Lifecycle	Classification	*{involved people}*
Meta-metadata	Langstring	*{Controlled vocabulary}*

3 Web Harvesting

The process of collecting and scraping the data off the web pages is called web harvesting. This includes the data shown on the web page and the data that is hidden and/or not shown. The web harvesting process is usually done by using computer programs (software) (Olston & Najork, 2010). These programs are generally known as web spiders or web robots. The harvested data can be stored in any format, such as in database form, JSON records, or simply in a sheet. Using web harvesting, we can crawl any amount of data, from simple web pages to a massive repository of web pages or resources.

In this section, we describe the harvesting policies the user needs to follow in order to collect data from the web in an efficient manner. Also, we describe the two types or techniques of harvesting, namely general harvesting and focused harvesting.

3.1 Harvesting Policies

Before harvesting any data on the web, one must have the right to collect this data. The rights of the data is owned by their authors/creators. Therefore, the copyrights should be checked before harvesting, or one should contact the authors or owners to obtain their permission to crawl the data from their portals. There are many copyright licenses available, and each one has different rules and specifications. If the copyright policy permits harvesting the data, one needs to follow the harvesting policies to collect the desired data from these web pages. There are four main web harvesting policies: the selection policy, the revisit policy, the politeness policy, and the parallelization policy (Castillo, 2005). The description of these policies is as follows.

- **The selection policy**: The size of the web is huge. Nowadays, there is a massive amount of web pages, and each web page can contain a large amount of data. Thus, the entire web cannot be harvested. In order to harvest some data from the web, one needs to set up a target by specifying the required type of data, the amount of data, and the number of web pages that contain this data.
- **The revisit policy**: After crawling a set of web pages that have been specified based on the previous selection policy, the content of these pages may change due to the dynamic behavior of the web. Therefore, in order to keep the harvested data up to date, one needs to revisit the already harvested web pages to crawl the updates and then update the database of the harvested data.
- **The politeness policy**: The web pages are hosted on servers, and these servers have resources, such as the memory and the bandwidth, which are limited. The process of harvesting a web page includes downloading that web page. The download will require the server resource to make your download request. So, the larger the harvested web pages, the larger the required resources. It is best to remember that many other users use or visit the web pages you are harvesting. Therefore, one should not overload the servers with requests to harvest many web pages simultaneously and, thus, prevent other users from using these web pages. It would be best to harvest data from the web politely. One can add pauses between sequences of requests so that the resources of the harvested resources are not monopolized.
- **The parallelization policy**: Some crawling software offers parallel crawling. This means that the user of the crawling software can run many crawlers at the same time. Using this approach, the download rate will be maximized, and the overload rate will be minimized as much as possible. The parallelization policy states that when the parallel crawlers are used, one needs to make sure that these parallel crawlers do not visit the same page severally. The web pages ought to be visited by only one crawler each. This will avoid wasting the resources of the servers and maximize the download rate.

3.2 General Harvesting

The general harvester is designed to crawl data from any web page without the need to modify the specification or the design of the harvester. The only changed item is the URL of the web page (Olston & Najork, 2010). This type of harvester has the main advantage that it is developed once and then used for crawling any web page. Despite this main advantage, it is limited regarding the amount of data that can be harvested since each web page has a different structure, which makes tracking the data on the page more difficult.

3.3 Focused Harvesting

Due to the limitation on the amount of data crawled using the general harvesters, the developers can design a focused harvester designed to crawl data based on a specific topic or portal (Johnson et al., 2003). The developer analyses the structure of the desired portal or repository they want to collect data from, then design and develop a harvester that follows the structure of that portal to extract the required information.

The main advantage of the focused harvester is that it maximizes the amount of harvested data since the web page structure is analysed and the position of the data known so that it can be easily harvested. Furthermore, some website developers use the existing templates when designing their portals. From that, we can take advantage of these templates and develop harvesters based on the structure of the template that some of the web pages use. The main disadvantage of the focused harvester is that the developer needs to design a crawler for each repository or portal. This will lead to more work designing different crawlers for different portals, especially when the data that needs to be collected comes from many repositories. Thus, it is time-consuming for the developers of the crawlers.

4 Metadata Mapping

The harvested data from the web pages will be stored using the following pattern:

```
<field name> : <value>
```

`<field name>` is the name of the information that will be stored in your database after harvesting it from the web page, such as “title”, “abstract”, or “keywords”. You can name these fields as you like or in some cases, the designers of the web page name these fields. Thus, the field names will be harvested with the data. The `<value>` part is the actual information of the harvested field.

As mentioned above, the LOM standard has many elements, and these elements contain the fields’ names. In most cases, the names of these fields in LOM are different from those used to represent the data in the portals. For example, some could name the field that represents the title of a lecture as “*titel*” (in German), and the LOM standard has a field name that represents the same information called “*title*”. Therefore, we need to change the names of the fields of the harvested data to match the field name of the LOM standard. This process is called mapping, which is the translation of the harvested field name to another field name (Latif et al., 2021).

4.1 General Mapping

As in the general harvester, the general mapper can be used to map the fields from many repositories into the fields of the LOM standard without changing anything in the design of the mapper. Since the fields’ names by using the general harvesters will be the same for all repositories, the general mapper will use these fields and find their matching field in the LOM standard. The main advantage is the same as the advantage of the general harvester; one mapper is developed for many repositories.

4.2 Focused Mapping

Since each data provider can use any of the available standards to represent their data or use their own representation structure, we require a common model for all the harvested data. To store the harvested data using one standard, which in our case is the LOM standard, we require all the information to follow the same structure in terms of the hierarchy of the data and the field names that represent the actual data.

Each focused harvester needs a mapper to match the field names in the LOM standard. These types of mappers are called focused mappers since each focused harvester needs a mapper. The main disadvantage of this type of mapper is that it is time-consuming for developers since they need to develop a mapper for each repository. This problem will occur especially if the number of focused harvesters is big.

5 Results

After the mapping stage, the processed data can be stored in different formats. One of these formats is the JavaScript Object Notation (JSON). The JSON format is used to store data that can be parsed by computers. This format is characterized by being human-readable and language-independent (Nurseitov et al., 2009).

```
{
        "title" : "How to store data using the JSON format. The easy guide",
        "author": {
                    "firstName" : "John",
                    "lastName" : "Smith"
                 }
        "publicationDate" : "01.01.2021",
        "abstract" : "In this article, we describe the process of storing data using
the Javascript
                     Object Notation (JSON) format. The JSON format is human
readable…"
}
```

Fig. 3 Example of a record that describes the information of an article using the JSON format

Another benefit of the JSON format is that the data can easily be stored, processed, and exchanged between different repositories. This becomes obvious when sharing the data of resources that are classified as open resources, such as the Open Educational Resources (OER).

The JSON format follows the pattern:

```
<field name> : <value>
```

This pattern can have any number of subfields to add more complexity and structure to the stored data. The files that will store the data using the JSON format will get a.json extension. Figure 3 shows an example of a JSON record that describes an article.

6 Storing the Results

After harvesting and mapping the crawled data from the web pages, the processed data is stored. One can use any storing method to save the processed data. It can be stored using JSON files with a.json extension, in a rational database management system, or in an index.

An index is a method to store a collection of documents to facilitate the search process. The index can be treated as a table in a rational database management system (Divya & Goyal, 2013). An example of an indexing system is Elasticsearch, which is a search and analytic engine for all types of data.[3] The main characteristic of Elasticsearch is that you can search the index almost in real-time. The Elasticsearch index can contain mapping rules that control the fields and the data that will be stored inside the index.

7 Harvesting Tools

There are several ways to harvest data from the web. Some need programming skills, while others do not require any knowledge in programming and software development. In this section, we explore different tools and libraries that are commonly used for harvesting data from web pages.

7.1 Harvesting Using Visual Tools

Data can be harvested using the available visual tools. The user of such tools does not need programming knowledge. Most of these visual harvesting tools are web-based, therefore, installing the tool on a device is not required. Despite the previous advantage, one of the limitations of the visual tools is that the harvested data requires more scrubbing. The harvested data is not clean and needs more work after the harvesting process is completed. Therefore, more work for the user starts after harvesting the data from the web. Another disadvantage is that most of these tools are not open-source, and you need to pay for the license. Below are some of the most common visual tools used and a brief description of each of them.

- Apify[4]: A web harvesting platform that downloads data in a structured form. It has some ready harvesters for some of the well-known data sources, such as Google Maps, Facebook, and Twitter. Apify has a free trial plan for 30 days.
- Import.io[5]: Usually, large companies use this tool. This tool is easy to use, and no programming skills are required. Yet, the main disadvantage is that this tool

[3] https://www.elastic.co/, last accessed: October 10, 2021.
[4] https://apify.com/, last accessed: October 10, 2021.
[5] https://www.import.io/, last accessed: October 10, 2021.

has to be run by the enterprise by itself with minimal support from the developers. Import.io is a paid service, and the price depends on the number of web pages you plan to harvest.

- Zyte[6]: Formerly known as ScrapingHub, it is a web-based platform. Usually, enterprises use this tool to collect data from the web. For this, there will be a good amount of support from the developers' team. Furthermore, the company provides training for the enterprises that plan to use its harvesting tool. Zyte has a 14 days' free trial period.
- Octoparse[7]: It is a web-based tool for scraping data from the web. Generally, it is useful for collecting e-commerce data. The harvested data can be stored in different file formats such as Comma-Separated Values (CSV) and JSON. Octoparse has a free plan that allows you to build up to 10 crawlers. If you need more crawlers, there are other paid plans.

7.2 Harvesting Using Programming Languages

Most of the programmers or those who have some knowledge in programming prefer to use programming languages, such as Python and Java, to develop their web harvesters. There are many libraries available, and most of them are free to use. Each library offers a set of characteristics that specify how the library is harvesting the web and how it processes the harvested data. The main advantage of using programming languages for harvesting data from the web is that the harvested data has a much higher quality compared with the visual tools explained above. Below are some of the most common libraries that programmers use to develop web harvesters.

- Scrapy[8]: One of the most popular libraries used by programmers and developers to harvest data from web pages. It is written in Python. It is open-source, which means that it is free to use and modify. Scrapy is efficient when harvesting large amounts of data, and it is easy to understand and use.

[6] https://www.zyte.com/, last accessed: October 10, 2021.

[7] https://www.octoparse.com/, last accessed: October 10, 2021.

[8] https://scrapy.org/, last accessed: October 10, 2021.

- BeautifulSoup[9]: A library written in Python and easy to use. BeautifulSoup can parse only retrieved web pages. Therefore, you need to retrieve the web page first, then pass it to BeautifulSoup to start parsing it and extract information from the web page.
- Selenium[10]: It is a web harvesting tool written in Java. It also supports different programming languages such as Python and JavaScript. The main characteristic of Selenium is its capability of dealing with web pages that have dynamic content. It executes all the scripts before parsing them. This process will slow down the overall harvesting process, though, especially when harvesting a large number of web pages.
- Jsoup[11]: Jsoup is a Java library that is used to parse and extract information from HTML web pages. Jsoup is an open-source library. The library can retrieve the web page and then extract the elements. It is also efficient when a large amount of web pages needs to be harvested.

8 EduArc

The EduArc project[12] aims to provide a federated infrastructure for digital and open educational resources for teachers and students in Germany. We defined the requirements necessary to develop such an infrastructure from the teachers' point of view, which are the primary users of such infrastructure. Figure 4 shows the infrastructure of the EduArc project. The process starts with a set of crawlers that collect the metadata of educational resources from a set of repositories. Afterwards, a set of mappers will map the harvested data to the Common Data Model (CDM) of EduArc, which is designed based on the LOM standard. Then the mapped data is ready to be indexed in the Elasticsearch index. The search engine and the front end of EduArc allow the users to search the index and filter the results. Furthermore, the front end allows the users to add OER to the current index.

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[9] https://www.crummy.com/software/BeautifulSoup/, last accessed: October 10, 2021.

[10] https://www.selenium.dev/, last accessed: October 10, 2021.

[11] https://jsoup.org/, last accessed: October 10, 2021.

[12] https://learninglab.uni-due.de/forschung/projekte/eduarc-digitale-bildungsarchitekturen, last accessed: October 10, 2021.

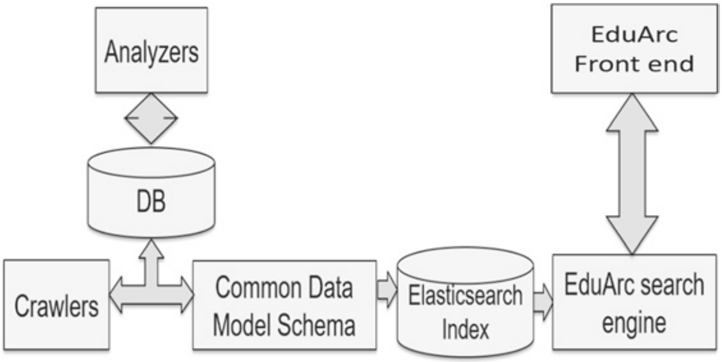

Fig. 4 The infrastructure of the EduArc project

9 Summary

In this chapter, we described the process of connecting the Open Educational Resources using the LOM standard. We illustrated the stages needed for such a process, starting from harvesting the data from the web pages to saving the results into a database or index. The harvesting process depends on the standard the OER providers used to model their metadata. The mappers also depend on the standard. The results can be stored in any format, such as JSON or CSV. We gave a brief description of the JSON format and its structure. Then, we listed some of the tools that help crawling the web pages. These tools can be visual, which does not require any knowledge in programming to run the harvesters. The other type of tool is used inside programming languages, which requires knowledge in programming. The latter tools render more high-quality data after harvesting the web pages compared to the visual tools. Finally, the EduArc project was described briefly to show the core concept and the workflow of the main infrastructure.

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Version Management in a Distributed Infrastructure for Open Educational Resources

Nadine Schroeder

Abstract

One concern of Open Educational Resources (OER) is to establish infrastructures, such as repositories, where learning materials can be uploaded and exchanged. Various initiatives all over the world are currently investigating technical developments for finding and sharing OER in higher education. In this context, the consolidation of individual solutions in a distributed infrastructure must be considered. When creating and editing content, modifications and adjustments can result in new versions of a resource and further developments of other users can lead to derivatives. Managing versions in terms of tracking changes and learning about new versions available is not only an issue for OER repository development, but also for interaction and discoverability in a distributed infrastructure. Therefore, version management can be considered as an approach to potentially improve the reuse and revision OER. This contribution discusses use cases of OER in the context of version management and presents approaches to managing educational material in a distributed infrastructure resulting in a concept of version management for OER.

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1 Introduction

A central issue of Open Educational Resources (OER) to establish infrastructures, such as repositories, where learning materials can be uploaded and exchanged. In higher education, various initiatives are currently investigating technical developments for finding and sharing OER. In addition to single OER repositories, distributed infrastructures, in which individual solutions are brought together to make OER more discoverable, also matter (see Sect. 2). When designing infrastructures for OER, version management is one relevant topic, as new versions occur when materials are created, reused, or edited.

To manage versions, version control is one solution which is widely used in software development as a concept for working on source code collaboratively as well as storing versions, tracking changes, and copying content for further development. Version control systems like GitHub are openly accessible hosting platforms for software code and allow developing and providing open source code. This aspect also applies to openly licensed educational materials. Although OER cover different types of material and file formats than software code, version management functions can be transferred as use cases for OER (see Sect. 3). When creating and editing OER, modifications and adjustments can result in new versions of a resource. Therefore, displaying an overview of versions with details of their differences are helpful for better comprehensibility. Especially when content is created collaboratively, the advantages of version management become clear. There is no overlap of changes and revisions can be transparently assigned to people so they can prove their involvement in the creation of the content. Furthermore, other users can modify content and develop it as their own resource. Thus, implementing the idea of OER, that materials can be used by others. In addition, the original author can receive recognition for a high-quality resource based on the number of reuses. Therefore, version management can be considered as an approach to potentially improving to the reuse and revision of OER. Still, transferring the versioning of OER onto platforms used for software development, such as GitHub, faces barriers. Users of OER without a technical background might find the procedures and application of these functionalities challenging and discouraging so that user-friendly interfaces are needed.

A further challenge concerns a distributed infrastructure for OER, where different aspects of connecting and referencing versions need to be considered to maintain consistent version information (see Sect. 4). The distributed and modifiable nature of OER results in users creating and sharing materials on different platforms so that the issue of duplicates needs to be considered. Besides, with a possibly high number of versions for one resource, search functionalities of a distributed infrastructure need to consider the consolidation of versions.

Consequently, this contribution aims at discussing OER in the context of version management and presenting approaches to managing OER in a distributed infrastructure, resulting in a concept of version management for OER. After describing the theoretical background of technical OER infrastructure and distributed version control (see Sect. 2), functions of version management are linked to possible use cases for OER (see Sect. 3). Finally, a concept for managing versions of OER in a distributed infrastructure, addressing issues such as metadata and persistent identifiers, tracking changes, further developments, as well as availability of new versions will be presented (see Sect. 4).

2 Theoretical Background

2.1 Technical Infrastructures of OER

The topic of OER is part of theoretical discussions and practical developments of technical infrastructures that enable educators and learners to find and share educational materials (Clements et al., 2015; Heck et al., 2020; Santos-Hermosa et al., 2017). OER repositories for storing OER are predominantly created by and for higher education institutions in Europe as well as the USA and are mainly designed for multidisciplinary educational resources (Santos-Hermosa et al., 2017). As the structure of educational systems is decentralized in most countries, higher education institutions have already established infrastructures to store OER. In Germany, institutional repositories exist at individual universities and in some federal states. Some repositories that enable the provision of OER for higher education teachers are already operating at certain institutions, others are still under development. To bring these individual solutions together, a common metadata standard is being discussed (see chapter Menzel). A distributed learning ecosystem can be seen as one solution for connecting OER services and improving aggregation of content and resources (see chapter Otto & Kerres). The idea of a distributed infrastructure for OER is based on a concept where different repositories and platforms containing OER are connected to a Core Hub through which the exchange of metadata takes place (Kerres et al., 2019). This cross-linked system aims at supporting findability and accessibility of OER.

Beyond the availability and accessibility of materials, the collaborative creation and use of teaching and learning materials are also part of the OER concept. This is reflected in the four elements *Search*, *Share*, *Reuse*, and *Collaborate*, which should be supported by an infrastructure (Atenas & Havemann, 2014). However, current repositories are mainly designed for storing and finding OER rather than fostering collaboration and social interaction between users, even though collaborative instruments enable users to participate in repositories and to develop OER together (Clements et al., 2015). Alongside collaborative features an active user community is needed to enhance the quality of OER and repositories (Zervas et al., 2014).

2.2 Version Management and OER

A version management system is a system used to record changes to documents or files (Franzetti, 2019). For each version of a file, information such as author name, time of change, and change notes is stored as the current status. In this way, changes can be tracked and older versions can be accessed or restored (Vijayakumaran, 2019). The advantage of distributed version control, such as Git, is that several users can asynchronously change the same version of a file, as the local changes are synchronised to a new version on the central server (Zolkifli et al., 2018). Particularly through the popular hosting platform GitHub, distributed version management has become publicly possible and simplifies collaborative work, thereby significantly supporting the open source movement. Software developers use version management to jointly create and edit code both internally and with external collaborators. Contributors to a project can propose changes that can be accepted or rejected by the maintainer and merged into the previous version. Changes can be tracked transparently and assigned to individual people.

In the context of *reusable learning objects,* version management was discussed (Brooks et al., 2003) and exemplarily realised for course content on a platform designed for creating, sharing, and reusing course content based on markdown (Salas, 2020). However, in this case, the course material was not published in an open repository, but within an access-restricted institutional platform. If content is not shared publicly, then licensing issues do not play a dominant role and collaboration is facilitated by the fact that authors highly likely know each other.

There are just a few use cases in the literature for the version control system GitHub as a collaborative learning environment where teachers and learners can interact within a course (Zagalsky et al., 2015). In another example, a research project showed that GitHub is used for the provision and storage of educational resources and that changes are mainly made by the project owners. However, other advantages of version management, such as copying and editing of materials by external people, are only used to a small extent (Schroeder & Pfaender, 2020). To exploit the potential of version management for the use of OER, one possible solution may be to transfer the version management processes into a user-friendly interface that facilitates access for users without technical background as GitHub, seems to be challenging for them (Ovadia, 2019).

3 Adaptation of Version Management for OER

The idea of OER is related to the 5R-concept according to Wiley (2014). These user rights describe options of open licenses when dealing with learning and teaching materials: Access to materials and the permission to save materials and their files as a personal copy (*retain*) are the prerequisite for the other rights to use, edit, and share OER. When dealing with version management, the aspects of *reuse*, *revise,* and *remix* matter while creating and editing new versions of OER. Reuse is possible by integrating content without changing it, while revising can be done by removing, adding, or rearranging content before using it in one's own material. Remixing means combining and changing different OER into new material. As a last step, creators or editors can share original or adapted content with others (*redistribute*).

First, the application of version management to OER is reflected in two use cases before discussing challenges related to scope and type of materials and formats. Using the example of GitHub possible adaptation of version management functions to OER are presented. Furthermore, educational tools applying such functions are described.

3.1 Use Cases of OER and Version Management

When version management is applied to the creation and modification of OER, two use cases can be distinguished. The difference lies in whether the adaptations are made to a resource or whether further materials are edited by external users independently of the original resource.

New versions of a material are created when content is changed, e.g., by additions or updates. This can be done by one author as well as by several people collaboratively. A clear presentation of the versions with options for comparing versions and changes plays an important role for comprehensibility. Changes to learning resources can be of various types and scopes. Formal changes may be minor corrections of grammatical or spelling errors or linguistic improvements.

Content changes can refer to updates and additions, but also to adaptations to individual contexts with different subject and local requirements. Didactic or technical changes in the arrangement of learning content or the use of tools are also conceivable. These changes can lead to a variety of new versions.

According to the idea of OER, the possibility of using and editing materials of others is a second use case which can be connected with version management. Users can adapt the material of an author to their individual contexts and make it available again so that besides the original resource, derivatives by different users might exist. Version management functions can support this use case by linking the original resource to the modified derivatives. This connection leads to the original resource being linked to the derivative and, at the same time, all derivatives being listed consolidated with the original resource.

3.2 Material Types and File Formats

To apply these use cases to version control, types and formats of materials need to be considered. OER comprise different scopes and types of materials which extend to different levels (Kerres, 2016). Firstly, single materials such as presentation slides, images, audios, videos, exercises, or interactive elements are learning objects that can be directly reused and integrated into materials and used in teaching. Secondly, there are teaching units that consist of a collection of materials, for example, text documents together with exercises, as in an h5p[1] or SCORM element. Also, online textbooks or notebooks, such as Jupyter Notebook,[2] contain several collected materials. Finally, the third level contains entire courses from a learning management system or a MOOC platform.

These levels of granularity and modularity influence the practical application of OER. Reusing and sharing resources becomes more effective and flexible when learning objects consist of single resources. (Salas, 2020). This is also evident from the fact that teachers prefer to reuse materials with a smaller scope (Schroeder & Krah, 2021). Therefore, it is necessary that OER repositories enable the provision and subdivision of resources into thematic units showing single elements.

Besides material types, open file formats play an important role in OER in the context of version management. On the one hand, the idea of OER is that content can be further processed without technical restrictions using openly accessible

[1] https://h5p.org/.

[2] https://jupyter.org/.

tools. On the other hand, open text files enable utilising the advantages of version control, such as the display of differences between versions.

3.3 Principles of Data Versioning

Besides software code, versioning has been applied to several use cases of data management (Klump et al., 2020a). The Research Data Alliance developed principles of data versioning (Klump et al., 2020b) oriented to version control of software code. These principles of data versioning can also be considered relevant for learning resources since they can be revised, released as new versions containing several materials in one resource or different file formats, as well as derived from other resources.

A changed instance of a dataset that is produced during data production is called a *revision,* whereas a *release* indicates a new data product after several revisions during the production of a dataset. The nature and significance of the change should be described. As part of the data versioning principles data repositories should consider different *granularities* and *manifestations* of data. Datasets may be combined into collections containing different sub-collections. Therefore, both granularities, collections, and datasets, need to be identified and versioned. Likewise, the same dataset may be occurred in different file formats so that the same content has different manifestations that need to be identified and connected. Furthermore, a release should contain information on its provenance when it is derived from other data products.

3.4 Version Management Functions for OER

GitHub, as a platform using functions of Git, enables version management during collaborative software development. GitHub functions can be presented as a workflow (see Fig. 1), where a creator initiates a project for producing material (black process). This content can be modified by contributors as part of the project and fed back into the main material (blue process). In addition, a material can be copied by other users, modified, and reported back to the original author (green process).

In addition to making source code available, GitHub can also be used for version management of documents, so that application scenarios for OER are possible. Some processes presented below can be transferred to different scenarios for educational resources (see Table 1).

Fig. 1 GitHub workflow of selected processes. (Own illustration)

The main function of version control is saving changes with *commits* and maintaining a history of those changes as well as assigning them to authors. This is essential, especially for the development of software, to be able to revert to

Table 1 Git(Hub) functions and transfer to OER (Own illustration)

Function	Relevance for software development	Transfer to educational resources
Release	Providing an interim state/stable version	Providing updated or corrected content as a new version
Commit	Save changes	Overview and transparency of changes
Diff	Display and comparison of differences and deviations (esp. for source code)	Display and comparison of differences and deviations (esp. for text files)
Fork	Splitting off a project for own development	Copy a resource for reuse
Branch	Ramification within a project for separate development	Subdivision of a resource into individual elements
Pull Request	Returning improvements or further developments to maintainer	Returning improvements or further developments to creator of a resource
Merge	Accepting changes and joining requests to original project	Accepting changes and joining requests to original resource

a previous, stable version in case of identified errors. However, individual or several authors working collaboratively with documents also benefit from considering older versions of a resource and restoring them if necessary. Change comments, known as *commit messages*, can be a valuable support in tracking changes between versions. However, social coding generates many more changes than revisions or adaptations of learning resources. Especially providing several revisions consolidated in a new version in as a *release* seems to be relevant for OER (see Sect. 3.3) and can be associated to the first use case (see Sect. 3.1). To illustrate the types of changes that have occurred among versions for users, the concept of semantic versioning (Preston-Werner, n. d.) uses a notation of three digits, e.g., 1.2.3. The first digit indicates major revisions, e.g., incompatible API changes. Minor revisions are made by adding functionalities to a new version, marked by increasing the second digit. Corrections such as bug fixes are tagged by a patch with the third digit.

With the *Diff* functionality, deviations in text files are displayed character by character, which is indispensable for the traceability of source code. Especially in the collaborative creation of learning resources, viewing exact deviations can contribute to quality control. However, OER are predominantly binary files, e.g., images, which are formatted and need to be interpreted by a programme. In contrast, text files just need a simple editor to be readable. That is why conversions from binary files to text files would be necessary, for example via Pandoc,[3] to be able to compare content of different files. This option exists for documents (docx, odt), books (epub) or tables (csv) with the target format Markdown, among others. However, this option is not feasible for many file formats. Special programmes such as pdftotext offer the conversion option for other file formats, but these are lossy and only give a rough overview of changes (Haenel & Plenz, 2014). For other file formats, such as image, video, and audio files, matching is technically possible but resource-intensive, for example, transcribing spoken audio content and comparing the transcripts automatically to highlight the differences.

A *branch* creates ramification within a project, creating different working environments for developments that can be fed back into the project (see Fig. 1, blue process). This functionality can be applied to learning resources when a material can be divided into individual elements in terms of a smaller granularity, for example, book chapters or learning units of a course. These elements can be edited or added in a single branch by individual users and integrated into the entire material if necessary.

A project can be split off to expand or test one's own development based on the code. The copy remains linked to the original so that further developments can be displayed with the original record. This *fork* method can be adapted for learning resources to create the basis for a derivative as described in the second use case (see Sect. 3.1). In this way, a material can be adapted to individual contexts (see Fig. 1, green process). Authors can trace who copied and edited their materials and other users have an overview of further versions of this material.

Pull requests can be used so that editors can inform the creator of the original resource about changes. It is up to the creator of the project to decide whether they want to integrate the improvements or adaptations into their materials and versions in the sense of a *merge*. In this way, learning resources can be linked or integrated into each other, for example, in the case of independently created text parts.

[3] https://pandoc.org/.

3.5 Educational Tools Using Version Management Functions

For a first insight into possibilities of transferring and using version management functions for OER, tools used in the educational context were analysed. It was found that these tools used for different material types and scenarios partly applied version management functions (see Table 2).

Collaborative writing and editing tools like Etherpads, e.g., HackMD, or Wikis provide an overview of version history and change messages as well as comparisons of differences. For example, Wikibooks enables the collaborative creating of open textbooks based on the Wiki software Mediawiki.

Several learning resources adapt the fork method to allow users to copy resources of others and modify or develop content for their individual needs and ideas. Examples for tools applying these functions are Scratch for learning pro-

Table 2 Tools for creating and editing learning materials

Tool	Link	Description	Collaborative editing	Version history + commit messages	Diff	Fork
Wikibooks	https://de.wikibooks.org/wiki/Hauptseite	Open Textbooks	x	x	x	
HackMD	https://hackmd.io/	Etherpad	x	x	x	
Scratch	https://scratch.mit.edu/	Programming				x
LearningApps	https://learningapps.org/	Interactive learning content				x
GeoGebra	https://www.geogebra.org/	Apps for Maths				x
SlideWiki	https://slidewiki.org	Presentation files	x	x		x
Tutory	www.tutory.de	Work sheets				x
Memucho	www.memucho.de	Exercises	x	x	x	x

gramming, Learning Apps for interactive learning content, SlideWiki for presentation files, Tutory for work sheets, or Memucho for learning exercises.

Some OER-repositories in Germany are based on the software edu-sharing[4] which, like others, focusses on storing resources rather than collaborative editing or exchanging content. New versions can be created for authors in their workspace, viewed, and restored if necessary. The last modification date gives external users an indication of new versions, but further modification details are not visible.

4 Version Management in a Distributed OER Infrastructure

Transferring version management functions to OER can be included in a concept of version management for OER in a distributed infrastructure which addresses issues such as metadata and persistent identifiers, tracking changes, further developments, as well as availability of new versions. Selected functions for managing versions and reusing, editing, and sharing materials are presented below. Special attention is paid to specifications of a distributed infrastructure that focus on discoverability and display of materials and their versions. Besides, it needs to be considered that a distributed infrastructure is based on the collection of metadata from various sources and repositories containing materials. Therefore, no content or files are available on a central platform, so that some processes of version management cannot be implemented as on an individual platform.

4.1 Persistent Identifiers

Persistent Identifiers (PIDs) are established for scientific publications, but OER are not usually assigned to this category. Also, the concept of OER, changeability through edits and adaptations does not correspond to long-term availability and permanent accessibility at first glance. However, to enable referencing and linking between repositories in a distributed infrastructure, PIDs are a necessary and useful integration.

Digital Object Identifiers (DOI) are widely used for scientific articles to permanently refer to digital objects. A DOI assigned to a digital object will remain

[4] https://edu-sharing.com/produkt/.

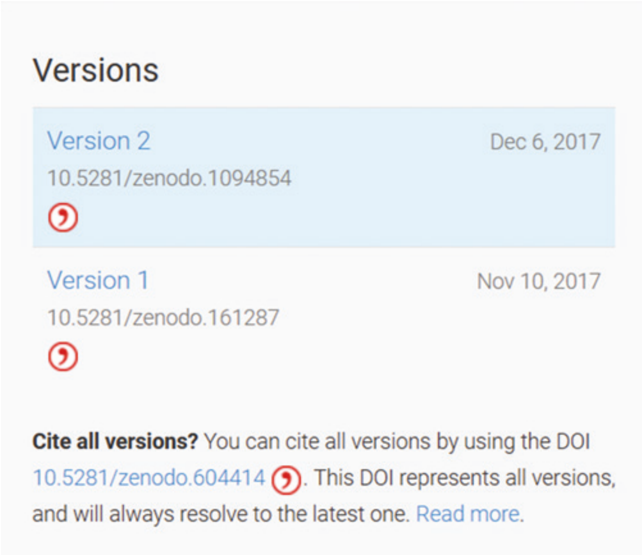

Fig. 2 Example for Zenodo DOI-Versioning. (Zenodo website of Czerniewicz et al., 2017)

throughout the object's existence, even when the location changes. As DOIs are meant to be permanent, they cannot be changed or deleted. Using the state "registered", the DOI will not be found unless someone knows the exact DOI string (DataCite, 2020).

In order to reference to individual versions as well as to connect all versions to one resource, the Zenodo platform uses a versioning concept (see Fig. 2) in which each version is assigned a DOI and the entire work is assigned a "concept DOI" that refers to all versions (Zenodo, n. d.).

Zenodo's DOI versioning appears to be a good way of representing different versions of OER, in that both individual versions and the entire dataset as a total resource receive a DOI. Adaptations of teaching materials lead to a large number of versions that are classified as no longer up to date or incorrect and would normally be deleted so that they do not remain in circulation. However, PIDs ensure that they and associated content cannot be deleted. One possible solution is to archive these versions so that the DOI remains up to date but is redirected to the "concept DOI" and other available versions can be accessed here. This solution can also be an option for users who want to assign a DOI only to selected versions Thus, it could be integrated as an optional feature.

Following this concept, various versions would be consolidated in a dataset of one resource so that users have a better search experience as they do not find several similar results for one resource. It makes sense to find only the most recent version and display it in the results list. As a requirement for search functions, it is therefore necessary that older versions are no longer integrated in the search index.

4.2 Metadata

Metadata for OER are based on standards such as Dublin Core, a general description of electronic resources, as well as LOM (Learning Object Metadata) for the description of learning objects. With regards to versioning, Dublin Core offers the property *relation* (DCMDI, 2021) with sub-properties such as *has Version / is Version Of* and *references / is Referenced By*. LOM contains *version* within the element *lifecycle,* which describes properties of the history and current status of the learning object and identifies the people and organisations involved in its creation (IEEE Std, 2020). Whereas *version* in LOM presents the status in terms of a version number, Dublin Core allows specifically linking of versions and records. Therefore, Dublin Core provides appropriate elements for applying version management.

New versions of one's own material can be linked to the metadata field *has Version – is Version Of*. Since some OER repositories, such as the edu-sharing software, offer the function of uploading a new version, these can also be included in a distributed infrastructure. Other repository software does not offer this function of adding a new version to a record. Instead, users can create a new record and link it to the previous source record with appropriate metadata. This new record needs to be recognised as a new version of the original record and mapped to it which can be seen as a requirement for a distributed infrastructure.

To connect the derivative with the original resource, the metadata field *references / is Referenced By* can be used as a link. As this possibility is missing in connected systems, the distributed infrastructure has to serve as a central place to hold this information. Describing and connecting underlying resources of a remix with metadata appears to be a complex matter that cannot be adequately mapped in a distributed infrastructure, so this has not been considered further in this context.

In case a new version or derivative is uploaded a second time in another external system, the infrastructure would need to have a duplicate check, which is not exclusively an issue of version management, but rather a general concern of mapping records of different sources in a distributed infrastructure environment.

4.3 Concepts and Functions of Version Management

As previously shown, functions and processes of version management can partly be adapted for OER (see Sect. 3) and are, therefore, integrated into this approach. Moreover, this concept is based on empirical findings from an interview study with higher education teachers aimed at identifying practices and behaviours in working with OER where requirements and relevant functions for OER infrastructures can be derived from (Schroeder & Krah, 2021).

In contrast to version control in software development, changes to educational material are not usually made live in online-editors. Rather updated material is uploaded as a new file. Therefore, releases can be seen as new versions provided with a new PID rather than single modifications as revisions (see Sect. 3.3). Releases can serve as basis for a version history to obtain an overview of different versions of a resource. This includes information such as DOI, person, date, and details of version changes (see Fig. 3). As described, the concept comprises that the entire resource receives a DOI automatically, while authors can optionally assign a DOI when uploading a new version. Version numbers can be realised as single counted digits rather than using the concept of semantic versioning. Since not every single change is saved as a new release, the transparency of changes is saved and realised through commits.

To be able to track differences between versions, change comments serve as a reference point (Schroeder & Krah, 2021). Authors can add these *commits* as

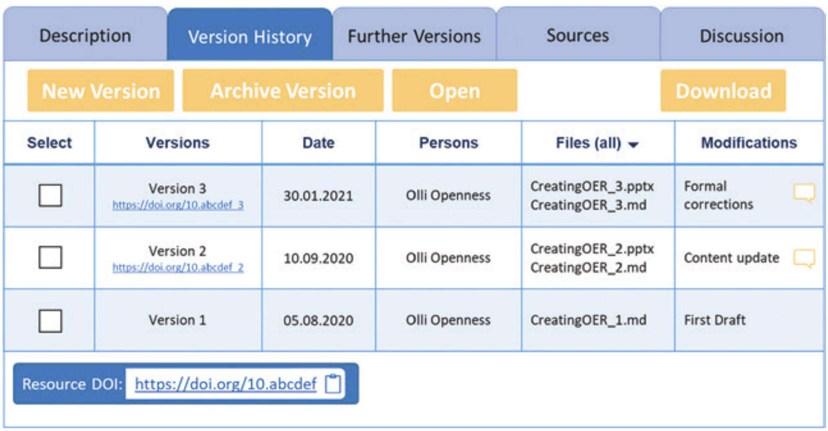

Fig. 3 Version history. (Own illustration)

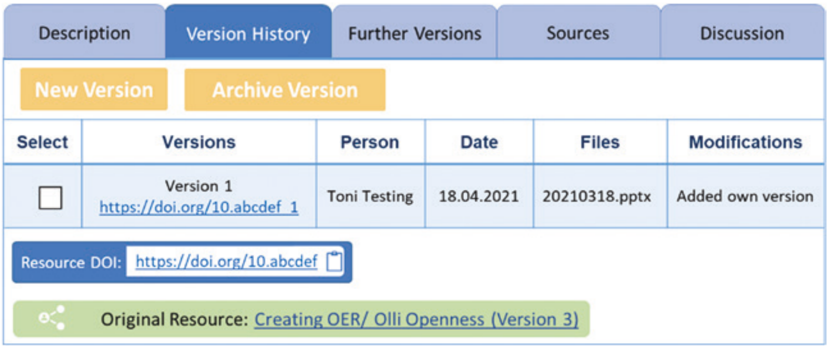

Fig. 4 Added derivative. (Own illustration)

release messages while uploading a new version. Tracking character-specific changes using the function *Diff* to compare two versions with colour markings are hardly to realisable in a distributed infrastructure as content is not stored.

According to the Data Versioning Principles, granularity and manifestation of materials and files need to be considered. Therefore, a filtering option within each dataset might be a possibility for individual repositories. Especially for materials with a larger scope, it is possible to select different material types to show a subdivision into separate content elements. In addition, uploading different file formats is relevant.

Higher education teachers reported that they were very interested in learning about the external use, editing and further dissemination of their materials (Schroeder & Krah, 2021). To be able to trace which derivative is based on which resource, it is important to maintain a connection to the original material. The GitHub-function *Fork* can be used for this process (see Sect. 3) and is realised in this concept. Applying this, an editor copies a resource into a new dataset by clicking on "Add own version", where the connection to the original resource remains visible and own versions can be added and uploaded by the new owner of the resource (see Fig. 4). At the same time, this new resource is added to the original under "Further versions" in order to provide an overview of reused and edited materials. This can give both the original author and external visitors indications about further developments and possible uses (see Fig. 5).

Version control also offers functions for cooperative development and usage of content, for example, returning improvements to the creator of a resource via pull requests or merging requests to the original resource. These aspects are more

Fig. 5 Overview of derivatives. (Own illustration)

relevant for a stand-alone platform, therefore, they are not focused on in presenting a distributed infrastructure.

4.4 Availability of New Versions and Derivatives

When authors upload new versions, the difficulty is how users become aware of this since they usually download and store resources in personal environments rather than consulting repositories or websites. Especially when thinking of a distributed infrastructure, finding out about new versions and derivatives is a major problem because resources are stored in disseminated repositories and users may no longer be aware of their place of origin or do not look for the specific dataset. However, it may be interesting for users to know if new versions exist of a material. A sensible solution for this concern will be a central contribution to realising version management for OER in a distributed infrastructure.

In the context of scientific publications, Crossref has addressed these issues with its service Crossmark, where a "button gives readers quick and easy access to the current status of an item of content, including any corrections, retractions, or updates to that record" (Vickery, 2020). This allows users to identify published versions of scholarly content. Readers click on the button *Check for updates* on the publisher's website or within the PDF file, whereupon a popup box appears showing the current status of the document. In case an article has updates, a Crossref DOI link directs readers to the current version on the publisher's website (Meyer, 2011). When a correction replaces the earlier version completely, the DOI of the corrected content will be the same as the DOI for the original Crossref deposit (Lamney, 2014).

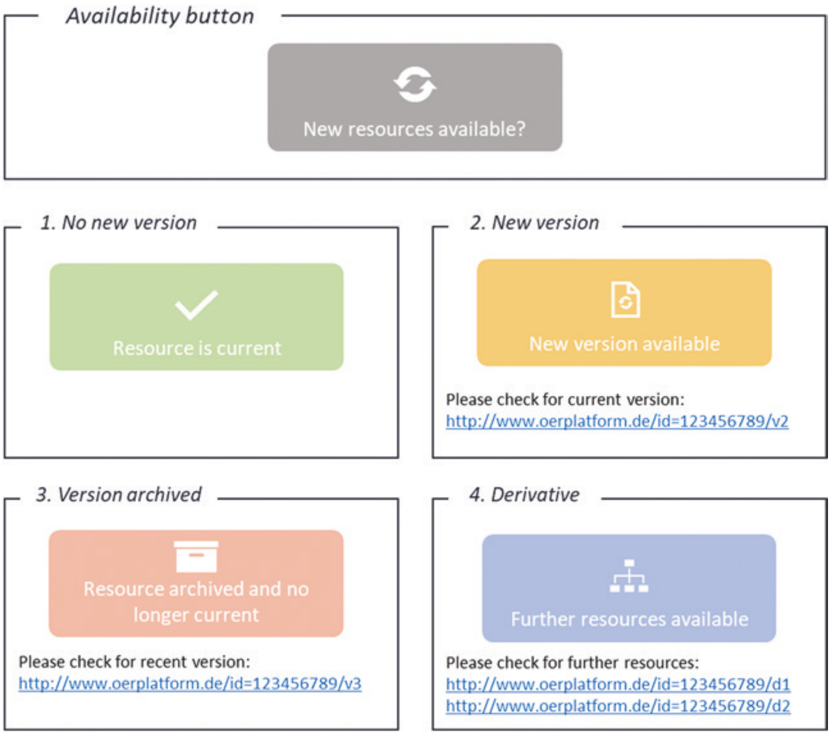

Fig. 6 Availability of new versions and derivatives. (Own illustration)

This concept can be seen as a solution to be adopted for OER, when users check if new versions or derivatives of a resource are available and are directed to the appropriate repository the resource is stored in. An adaptation of the Crossmark button can be integrated into suitable materials as well as into datasets in case versions of a resource are stored in different locations. By clicking on the "availability button", four different views related to four use cases may appear (see Fig. 6). A resource can be original and current so that no further updates will be indicated (1.). If a new version is available, a link is added to get to the corresponding resource in the current version (2.). For an archived version, which is no longer available, a link to the most recent version is provided (3.). This check for the availability of new versions can also be applied for derivatives. In this case, all connected resources are linked (4.). This concept enables users to check directly against the material at hand whether new versions or derivatives are available, regardless of their location. Therefore, this contribution provides a solution for managing versions and derivatives in a distributed infrastructure.

5 Conclusion

This contribution discussed use cases of OER in the context of version management and presented approaches to managing educational materials in a distributed infrastructure, resulting in a concept of version management for OER. It could be shown that version management functions and processes from software development are already partly adapted by some educational tools and can be transferred to OER. In addition, concepts related to the publication of scientific articles and the management of research data may also be applied to OER. The presented ideas on version management for OER represent an approach for further development, taking into account the challenges of a distributed infrastructure.

Overall, infrastructures need to be well designed to make it easy for users to find and share OER in higher education. Especially, the exchange of materials and cooperation in communities should be given greater focus and support by infrastructures.

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Developing a Metadata Profile for Higher Education OER Repositories

Michael Menzel

Abstract

To provide Open Educational Resources (OER) according to the recognised FAIR principles (improve Findability, Accessibility, Interoperability, and Reuse of digital assets), it is necessary to describe the educational material by means of meaningful metadata. There are conflicting demands to comply with. On the one hand, the educational resources should be described in as much detail as possible for accurately fitting search results. On the other hand, only strictly necessary information should be obligatory to keep the obstacles for authors as low as possible. An additional goal is to allow easy connection between repositories, thus allowing federated search and harvesting of metadata, for example, by search engines or other interested parties. Operators of OER repositories from several federal states in Germany (HOOU, OERNDS, ORCA.nrw, VCRP, VHB, ZOERR) have developed a metadata profile focussing on OER in the context of higher education. The initiators strive to reach the mentioned objectives and to establish a standard in the field. The metadata profile is based on the well-established Learning Object Metadata Standard (LOM). The chapter describes the decision process and why certain choices are made to reach the intended goals. Furthermore, the importance of editorial supervision for a sound quality of the material and metadata will be discussed. The chances and challenges are illustrated based on practical experiences with the establishment and daily operation of the *Zentrales OER Repositorium der Hochschulen in Baden- Württemberg (ZOERR)*.

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1 Metadata and Why They are Needed?

An association of OER repository representatives of several federal states of Germany joined forces to promote technical infrastructure developments for OER in higher education. These are the *Hamburg Open Online University (HOOU)* for Hamburg, *Digitale Hochschule NRW* and *Hochschulbibliothekszentrum NRW* (project *ORCA.nrw*) for North Rhine-Westphalia, *Technische Informationsbibliothek Niedersachsen (twillo.de)* for Lower Saxony, *Virtueller Campus Rheinland-Pfalz (oer@rlp)* for Rhineland-Palatinate, *Virtuelle Hochschule Bayern (vhb.org)* for Bavaria, and *Universität Tübingen (zoerr.de)* for Baden-Wuerttemberg. As the author works for the latter, the operational experiences are described from the perspective of the *Zentrales OER Repositorium der Hochschulen in Baden- Württemberg (ZOERR)*.

The importance of focussing on metadata when planning OER services can be justified by three main reasons. Firstly, metadata are a cornerstone for presenting good and matching results to anyone searching for OER. Secondly, metadata are supposed to offer an overview, helping the user to easily assess if an open educational resource is suitable for the intended purpose. Thirdly, standardised metadata simplify the sharing of resources between repositories or with other interested parties such as specialised search engines. In general, it can be stated that valid metadata support quality assurance and that standards facilitate this considerably.

A comprehensive overview about metadata and their importance can be found, for example, in (Haynes, 2018). Metadata schemes are structured agreements on the syntax and semantics of descriptive data for objects. Objects in this sense are often themselves data. Therefore, the data describing them are called metadata. Every subject or discipline has varying requirements in terms of metadata. This leads to a significant number of metadata schemes. Once a scheme has been adopted by a standardisation organisation, it becomes a metadata standard. Even though most standards have been designed for certain disciplines, they still allow general use in many circumstances.

Concretisations concerning certain communities, applications, or extensions and combinations of metadata schemes are recorded in so-called metadata *profiles*. They describe and clarify the designated use of metadata schemes by providing the following information: which properties and types of the scheme are used, which restrictions will apply, and which vocabularies have to be used.

A vocabulary is a set of words, or in our context rather values, defining the permitted entries in a metadata property. In simplified terms, these entries can be just arbitrary text, numbers, or a vocabulary, depending on the semantic. Ideally, the vocabulary is a *controlled vocabulary*, in other words, the values are defined and fixed. Controlled vocabularies allow to automatically process and agree on the meaning of metadata in data exchanges between partners.

Controlled vocabularies can be managed in different ways. For sustainability reasons, the Simple Knowledge Organisation System (SKOS) is a good choice to enable efficient maintenance, an automatic deployment via the internet, and the possibility to offer the values in different languages. SKOS is a recommendation of the World Wide Web Consortium (W3C) and allows to use the vocabulary as linked data too. For more information about SKOS, see (Miles & Bechhofer., 2009).

2 Why Do We Not Employ an Existing Standard Directly?

Enquiries have shown that many standards are either not established, not suitable for learning objects, or simply not sufficiently disseminated (Ziedorn et al., 2013). A decent overview of metadata in the context of OER can be found, for example, in (Steiner, 2017). The widely used Dublin Core schema is too general and not able to meet the specific needs of OER. The ELAN Application Profile (ELAN is an acronym for *eLearning Academic Network Niedersachsen*) defines a minimal set of metadata for learning objects and appears to be a promising approach for our goal (DINI AG Metadaten et al., 2005). Yet it distinguishes very strictly between courses and content, for example, everything needs to be part of a course, which is not flexible enough. Furthermore, the profile has not found widespread distribution. In the educational context in Germany, the so-called *Erweitertes Austauschformat* (EAF) had been used by the *Medieninstitut der Länder* for many years. The format has been frozen since 2012, and it was announced any further development would be transferred into a new LOM-EAF scheme (AG Mediendistribution & Dokumentation, 2012). Unfortunately, there is no published specification or documentation on this. Under the umbrella of the *Deutscher Bildungsserver,* the institute made efforts to specify a LOM-DE metadata profile (Schumacher et al., 2010). However, this specification never reached an official and recognised state. Apart from that, it has mainly the same extent as the original LOM and focusses on school education.

Therefore, we decided to adhere to the original LOM (IEEE, 2002). A compact overview of LOM and Dublin Core can be found, for example, in (Barker & Campbell, 2010). Despite its age and complexity, the Learning Objects Metadata Standard (LOM) is still the most used international standard in the field, focussing especially on objects suitable for e-learning (Haynes, 2018, p.73f.). Comments on the role of LOM in the repositories Merlot and Ariadne can be found in (Wiesner, 2010, p.34f.). Moreover, LOM is also used as a basis in the renowned OER Commons repository (OER Commons, 2014). Additionally, LOM has recognised mappings to the widely used Dublin Core metadata standard (IEEE, 2002, Annex B). LOM consists of nine categories covering a wide variety of fields to characterise learning objects in various respects. Even though this is favourable from an informational perspective, it is not that user-friendly as lecturers who author OER are often not willing to put in the effort to fill in long forms with metadata when uploading their OER. Therefore, given the manageability and the main goal of collecting a large variety of OER content, a sophisticated reduction of the standard was needed. The means and results in the form of a metadata profile for OER in the context of higher education called HS-OER-LOM are described from chapter 3 onwards. Yet before, some thoughts on LRMI are given.

2.1 Learning Resource Metadata Initiative (LRMI)

The option to deploy the LRMI metadata scheme is a special case and deserves some remarks. The Learning Resource Metadata Initiative (LRMI) started a project with the same name in 2011 to establish a vocabulary for describing learning resources (see https://dublincore.org/about/lrmi/). For several years, the advantages of providing metadata as LRMI have been discussed in the community, for example, in (Haneefa & Chembrakuzhi, 2014). LRMI was not designed to describe objects with a monolithic set of metadata but rather for the use of so-called microdata. Microdata allow to tag content of websites in line with structured metadata. LRMI integrates parts from the schema.org standard (Ziedorn et al., 2013, p.6f.). LRMI development was led by the Association of Educational Publishers and Creative Commons. Meanwhile, it is curated by the Dublin Core Metadata Initiative. A feasibility study of the *Deutscher Bildungsserver* recommends the implementation of LRMI to serve search engines properly (Deutscher Bildungsserver, 2016, p.48). Another study on ten OER platforms was conducted by Campbell and Barker (2014). They state that a survey of LRMI implementations on these repositories found that "several projects noted that they had not observed any measurable impact as a result of implementing LRMI" (Campbell et al., 2014, p.11). Nevertheless, the parties also said "they also felt it had been beneficial to be involved in the LRMI Implementation Projects and to be at the 'cutting edge' of metadata technology" (Campbell et al., 2014, p.11). It remains unclear how the large search engines exploit the metadata from the websites as the algorithms are secret.

LRMI may have its advantages but because of the concept of microdata integrated in the content, it is not suitable for the exchange of structured metadata between connected repositories.

3 Which Roads Lead to a Good Metadata Profile?

As discussed in the previous chapter, the developed metadata profile for higher education OER (HS-OER-LOM) builds upon and is compatible with the internationally established LOM standard. While LOM supports a comprehensive description of OER, we were confronted with the task to reduce the coverage in a way that it can be conveniently managed. This resulted in the following leading question: How can a good balance between sufficient and user-friendly (for submitters) metadata be reached? Potential users need sufficient information to find suitable material, while creators of material should not be discouraged by overly demanding metadata requirements. To find an answer, the following questions were considered.

How much and which metadata can be requested from authors? Basic information about the OER such as title and license would be essential, as well as some information regarding the subject. It is needed for the correct usage (license information) of the OER, see, for example, the TULLU rule (Borski & Muuß-Merholz, 2016). Yet, more information takes more effort that submitters are often unwilling to invest (Hielscher et al., 2015). Also, various pedagogical data can often only be supplied by someone who is trained in didactics, which does not apply to all OER authors.

Which metadata can be automatically produced, and which need to be entered individually? Automatically generated metadata such as the publishing date or technical format of the OER takes no human effort and should be included if it is of actual use.

What can be done by editorial staff who has no specialised knowledge in the respective fields? Higher education covers a wide range of subjects and editors cannot have expert insights in them. This contrasts with journal editors who only cover a certain scientific field. Common bibliographic data and keywords can certainly be checked or provided by editors. However, content description is limited to a general level.

Which metadata is actually given by authors in practice, and which fields are ignored? Without question, data such as title and author are always supplied, and the need for a license can easily be motivated. Anything else has to be argued. A meaningful description going beyond the title is certainly a valuable piece of information for people searching for OER. Real-life experience has revealed that this often has to be requested from the authors or done by the editors themselves. Another aspect is the unsurprising finding by (Hielscher et al., 2015, p.151f.) that fields with a given vocabulary to choose from are more frequently filled in than those asking for free text. The rather difficult issue of pedagogical metadata is addressed in the next question.

Furthermore, we considered whether the management of metadata is still worth the effort if metadata are not or only rarely supplied. Then the alleged benefit turns into a disadvantage—a matching OER is not found just because the data are missing. In this case, the alleged availability of certain metadata gives rise to false expectations. For example, let us take a look at fields regarding accessibility. Without question, accessibility information is desirable, and more effort should be invested to make OER also usable for functionally impaired students (Zhang et al., 2020). With a great deal of work focussing on this audience, substantial improvements in providing OER can be reached (Navarrete & Luján-Mora, 2018). There are repositories offering the possibility to enter metadata for accessibility along the way but without accompanying measures in this matter. The people running them report that those fields are ignored by the authors and the effort to supply information here is avoided. Consequently, a search mask promising to find OER fulfilling certain accessibility criteria gives rise to expectations which cannot be met. Thus, it is better to relinquish such data if the information cannot be ensured at least for a certain part of the OER provided.

What metadata are important especially for OER or learning objects? This issue deals mainly with pedagogical metadata. This covers various aspects like preconditional knowledge, curricular attribution, suitable age, time involved to work through the OER, etc.—they are helpful categories. Learning objects are distinct from material usually catalogued by libraries particularly concerning the pedagogic aspect. Yet there are several issues when considering the possibilities to make such attributions. The kind of the OER can have different forms. Pedagogical metadata in learning courses with several modules, maybe even developed on demand for specific lectures, can be provided more easily. This is due to the fact that a course already belongs to a certain didactic setting and has been developed with a pedagogical intent. In contrast, the labelling can be quite difficult for a small piece like an image, a video clip, or a contribution illustrating a topic in a concise way. The purpose of OER like these is that they are embedded and reused in other contexts. This and the possibility to modify the material are the main advantages of OER and they are made possible by open licensing. This flexibility, however, often hinders the supply of pedagogical metadata as, for example, a curricular attribution, a note on time needed, sometimes even the specification of a subject group. The educational openness of universities in contrast to schools also impedes such categorisation.

Therefore, it was decided to have only very few obligatory pedagogical metadata. In the end, only the *learning resource type* and *description* made it into the profile. The former has advantages for both sides—authors can choose easily from the controlled vocabulary and searchers find it useful to roughly filter the available OER for their intended use according to the type. *Description* in the context of LOM refers to comments on how this learning object can be used. This may be necessary for some kinds of OER. Additionally, it has the benefit that related but rarely used specifications, which would go into more specific pedagogical data fields in the original LOM, can be recorded here as well. Because of the mentioned considerations, any other pedagogical metadata has not been adopted into the profile. This decision was encouraged by the results of a survey among faculty staff conducted by the ZOERR at the beginning of the project. The results show that faculty staff search for content suitable for their lectures. During that process, they are not interested in pedagogical filters. The material is checked with personal expertise and the main criterion is the fit into their own teaching material, that is, the pedagogical suitability is a by-product of the personal review.

4 How Was the Metadata Profile Implemented?

The metadata profile has been formalised and is available as XSD schema, which can be used for validation of individual metadata. Furthermore, there are examples and an extensive description (Menzel, 2020a). The latest version can be found here: https://w3id.org/dini-ag-kim/hs-oer-lom-profil/latest/

As the description mentioned above, an overview article (Menzel, 2020b), and a specification (Menzel et al., 2021c), which extensively decribe the details of the HS-OER-LOM metadata profile, already exist, the focus here will only be on a classification regarding the necessity of the individual attributes, resulting from the considerations in the previous chapter. A detailed consideration of the vocabularies used is also made.

The profile requires obligatory metadata in a few places only. Our considerations for the implementation lead to four categories of metadata:

1. Obligatory metadata: *title, originator/author, license*. This information is strictly necessary to offer OER at all (rules for citation [Borski & Muuß-Merholz, 2016]).
2. Highly recommended metadata: *description, origin, language, learning resource type, persistent identifier, creation date, publishing date*. Most of these data can be provided easily or generated automatically. Only the description needs an effort by the submitter, yet is helpful from a user's viewpoint for a quick overview of the content of the OER. The persistent identifier, provided by the repository, is not obligatory. For OER which are linked and not uploaded onto the repository, a persistent identifier might already have been provided by the original source, or there may sometimes be doubts about the permanent availability of the offered OER.
3. Useful metadata: *keywords* and *scientific subject*. This information considerably facilitates the search for accurately fitting OER and is, therefore, desirable.
4. Optional metadata: *technical requirements* and *further persons involved*. For some OER, special applications are necessary to use them. These applications may not be well-known but can be common practice in a scientific field, for example, certain tools for data visualisation or statistics. Furthermore, hints on a correct import, for example, into a learning management system, might be very helpful. For this purpose, notes on the technical requirements should be included. When further persons or organisations were involved in the production of the OER, it is good practice to name them too.

The investigations in (Hielscher et al., 2015, p.151f.) clearly indicate that vocabularies offered to submitters of OER can significantly lower the inhibition threshold to fill in metadata. In two places of the developed metadata profile, a fixed vocabulary is used that is not taken from the LOM standard. Firstly, there are the learning resource types. Originally, LOM had defined this kind of metadata in a rather basic manner. Our investigations have revealed that many parties apparently consider this specification as inadequate. Therefore, they developed variants and extensions on their own. To the best of our knowledge, none of these could be established as a standard. Among the parties we looked at were EAF/LOM- DE (ELIXIR) (DIPF, 2021), LOM-CH, OER Commons (OER Commons, 2014), DuEPublico (Universität Duisburg-Essen, 2021), ILIAS, and Moodle. Eventually, we decided to develop our own vocabulary for the purpose, that is, with a focus on OER and higher education.

Secondly, a vocabulary for scientific subjects had to be defined. After some debate, the classification of university subjects by the German Federal Statistical Office (DESTATIS) was chosen (Statistisches Bundesamt, 2020). In the discussion about the new profile, involving various partners from all over Germany, the mentioned classification emerged as the best common ground. The classification depicts a multilevel hierarchy of the university subjects in Germany. By using this scheme, the granularity can be chosen by anyone in a compatible way. At the same time, when searching for OER, the subject filter can be narrower or wider.

Furthermore, the subject classification by DESTATIS is maintained and updated on a regular basis. In recent talks with members from the project Open Education Austria Advanced (which is a follow-up of a project described here [Lingo et al., 2019]), who are about to run OER repositories as well, it was found that they have their own, slightly different classification of subjects. However, they are interested in the metadata profile presented here and plan to adopt it as well. For more information on their repository called *OERhub,* visit https://www.openeducation.at/suchen/. Regarding the subject, switching to an internationally recognised classification scheme used by libraries, such as the Dewey Decimal Classification (DDC), is not feasible because many scientific subjects are not represented on a comparable level, especially new ones that have emerged in the last decades. For example, computer science is just a sub-item in the main class called "Computer science, information & general works", which also accommodates all kinds of topics that do not fit to another subject. On the other hand, "Philosophy and psychology" is a main class with several sub-items of fine granularity and does not even include religion, which forms a main class by itself.

Both vocabularies are implemented using the Simple Knowledge Organization System (SKOS). For the learning resource types see https://w3id.org/kim/hcrt/scheme and for the subjects see https://w3id.org/kim/hochschulfaechersystematik/scheme. Therefore, they are machine-readable. Every single value has a permanent identifier. The vocabularies themselves are not fixed permanently, though. Proposals for extensions and modifications can be put forward and discussed via projects in GitHub (Menzel et al., 2021a) and (Menzel et al., 2021b). Adopted changes can be automatically deployed by applications.

Let us now say a few words about keywords, which are simple terms in the specification of the metadata profile. The Baden-Wuerttemberg OER repository ZOERR distinguishes between free and fixed keywords. The former are entered freely by the author, while the latter are fed by a catalogue of common terms, which is a part of the Integrated Authority File (GND) of the Deutsche Nationalbibliothek (DNB) (Deutsche Nationalbibliothek, 2021). The facilitation through the fixed keywords yields several advantages. Spelling mistakes are avoided, and equal terms are named equally. Additionally, synonyms are covered by the vocabulary, that is, when synonymous terms are entered, they are automatically rooted back to the main term which makes matching requests more likely. For these reasons, the fixed keywords should be preferred whenever possible. Keywords that cannot be found in the catalogue can still be declared free keywords.

As it was pointed out in the beginning, LRMI is a schema recommended by various parties and can be regarded as an add-on because of its different light-weight nature (microdata). The findings by (Campbell et al., 2014), that the practical outcome cannot really be measured, are in line with the experiences of the ZOERR repository, which has implemented and exposed a very basic LRMI scheme in the HTML pages as well. Also, another profile using schema.org/LRMI is in development using the HS-OER-LOM metadata profile as one of the building blocks. It is about to be released and will be published in the format JSON/LD (Pohl et al., 2021). Its goal is better usability in the context of HTML and by Internet search engines. The *OER Search Index (OERSI)*, see https://oersi.de/resources/, utilises this profile.

Striving for standardisation both with the profile itself and the used vocabularies, the clarity in classification and description of OER is promoted. This leads to better search results when looking for OER and enables the automated exchange between repositories.

5 What is the Operating Experience with ZOERR like?

An overview of the beginnings and background of the *Zentrales OER Repositorium der Hochschulen in Baden-Württemberg (ZOERR)* can be found in (Rempis, 2017). The FAIR principles (GO FAIR Initiative, 2021) are an important guideline for repositories, too. Therefore, the following paragraph describes how the ZOERR considers these principles and which role the metadata profile plays in this.

Findability: Users can employ the unspecific search in an one-line search slot, like they are used to with other search engines. All metadata and content, that can be automatically parsed, is indexed. Users are so accustomed to this kind of search that it is standard and should be offered for usability reasons. Nonetheless, an optimal hit accuracy will not be reached this way in most cases. However, the extended search allows filtering with high accuracy by its defined metadata fields, even if it is sometimes considered an outdated approach. The controlled vocabularies for learning resource types and scientific subjects are very helpful in the selection. Likewise, the keywords based on the Integrated Authority File are helpful for finding similar OER. All OER hosted (not linked) by the repository obtain a handle, which is a globally unique and persistent identifier; every entry in the repository has a unique identifier. Identifiers are published on the top-level in the metadata of each record.

Accessibility: According to the principles of OER, the repository and its content can be used completely freely. Registration is only necessary for authors providing OER to organise the submission process sensibly. Metadata are harvestable using the OAI-PMH protocol. There is also a public REST-API. Both are open and universal protocols for information retrieval.

Interoperability: This can be viewed from two different angles. Firstly, there is a structural aspect. More precisely, a coordinated exchange of metadata with other repositories and interested parties can be achieved by utilising the jointly created metadata profile. Thus, the OER can be offered to a wider audience. The metadata specification and used vocabularies are openly available and the representation uses state-of-the-art formats. There are mechanisms for further development when needed. Secondly, interoperability can be seen regarding the OER themselves. As operators of the ZOERR, we try to foster open formats. Yet in the end, we are only intermediaries between providers and users. In this context, we have to come to terms with commonly accepted formats like Microsoft Office. Furthermore, authors are encouraged to also provide the editable sources of their materials, in other words, not only the final presentation in PDF, for example.

Reuse: All material that is hosted by the repository itself can be downloaded and used subsequently in the context of the user. This is fostered by the open licenses, and OER can be modified and enhanced by users. Each metadata record contains a minimum of mandatory terms, the supply of an (open) license and an authorship for all OER is obligatory, and all uploaded material and metadata is traceable to a registered user of ZOERR.

5.1 Editors—Who Needs Them?

Right from the start, the ZOERR repository was devised with an accompanying editorial supervision in mind. Consequently, it is not a self-publishing system. In running operations, this decision was confirmed as crucial and correct.

A workflow was established for publishing OER via the ZOERR. When the submitter uploads an object into the repository, a dialogue pops up asking for descriptive metadata. The submitter can but does not have to be the author. In the latter case, he might only upload the information he obtained from the author. The metadata can be entered immediately or whenever convenient. The object including the metadata can be shared among colleagues within the system for collaboration. New versions can be uploaded as well. When the OER is ready to be published, the submitter passes the material on to the editorial staff.

In our view, editorial supervision is necessary for the appropriate (formal) quality of the OER and metadata. Editorial staff cannot conduct an examination of the content itself because general OER repositories cover almost all areas of science, and a classic peer-review of all OER requires far too many resources, especially for many small pieces. However, in the daily work, the editors of the ZOERR make a valuable contribution by revealing private notes, unintended gaps, formatting errors, and such like in the OER submitted for publication. In such cases, they contact the submitters, ask for their intention, and offer support. The editors can also encourage the submitters to provide valuable metadata, for example, a concise description and reasonable keywords. Moreover, they lend active support with the metadata. Experience shows that this help is generally gladly accepted. An editorial process can also inhibit an arbitrariness in the metadata. As an example, note the *communities* in Zenodo, which are intended to cluster all the contributions in a reasonable way, see https://www.zenodo.org/communities/. Apparently, anyone can create a new community in Zenodo. Even though this idea sounds good, during an investigation by the author in the year 2020, the number of communities increased by about 300 each day, and about 15,000 communities existed in total. Obviously, this concept cannot be used in a practical way. Admittedly, there are (meanwhile) mechanisms to correct that (not investigated further) because another check in July 2021 showed a number of communities half as high and falling. The point is that curating metadata may help a lot when it comes to classification and findability.

When the editorial process is finished to the satisfaction of all sides, the new OER is then published together with a persistent identifier. For some OER that are significant and above a certain level of creation, the editors will also record the new work in the library catalogue. This is a step towards raising labour-intensive OER of high quality to a similar level as other publications of scientific papers.

5.2 Can we share?

The operators of ZOERR see it as an important and beneficial task to publish the OER in the ZOERR and to give access to suitable OER of other sources to a wide range of users. To this end, the exchange of metadata is necessary. A metadata profile like the one jointly developed by the operators of OER repositories for higher education renders this exchange possible. The ZOERR offers the metadata of its content via an OAI-PMH interface to the public. Arrangements were made with the *Hamburg Open Online University* and the OER repository of the *Virtueller Campus Rheinland-Pfalz (oer@rlp)*. Thus, a technical implementation could be realised to include the OER from these repositories when querying the ZOERR in such a way that search hits are presented in a transparent manner. To access the actual OER, the user is then forwarded to the corresponding repository. There are plans for cooperations with more partners.

6 What are the Results? How to Carry On?

Since there was no standard metadata scheme for OER in higher education, the need arose to reach an agreement on this. The main arguments here are findability of OER for users on the one hand and dissemination or harvest of openly licensed learning objects on the other hand.

We aimed to deploy an existing metadata standard scheme. As we pointed out, there were serious reasons to develop a scheme. To stay compatible with others, we specified a suitable metadata profile based on the internationally known LOM scheme, which focusses on learning objects. We investigated what information is useful for potential users and what can be supplied efficiently in daily business. The results were recorded as a XSD schema that can also be used for validation purposes of self-produced metadata. The schema is accompanied by an extensive documentation including examples.

We are convinced that a slim metadata profile like the HS-OER-LOM presented here is a vital basis for a continuous operation of a repository with consistently high quality. As operators of ZOERR, we have had positive experiences working on the basis of this profile but think that editorial support is vital in order to maintain the quality standard. However, this certainly depends on many more conditions, such as the precise kind of content, intended audience, providers, granularity of OER, etc. Quality assurance is a large topic to be discussed elsewhere and metadata is only one significant part of it. We argue that HS-OER-LOM is a reasonable compromise between preferable extent and practicable brevity. There is always a certain level of maintenance expenditure, but this remains manageable when limited to what is necessary. The linking-up with other providers is only possible in an economic way when agreeing on a clear and manageable scheme.

Furthermore, the profile is designed in a way that extensions can be carried out in a defined process in the future if the demand arises. To that end, there are GitHub projects for the metadata profile itself (Menzel et al., 2021c) as well as for the used vocabularies (Menzel et al., 2021a, 2021b). The specifications are made in a format with long-term availability in mind. The KIM metadata group for OER in the context of the DNB forms a framework for interested parties to discuss further developments (Kompetenzzentrum Interoperable Metadaten, 2021).

We are pleased that HS-OER-LOM is attracting attention from other players in the field like Open Education Austria Advanced. We hope that the metadata profile will convince others and find a wide distribution among the parties managing OER in the context of higher education.

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A Trusted Learning Analytics Dashboard for Displaying OER

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Abstract

Learning Analytics (LA) consists of miscellaneous steps that include data harvesting, storing, cleaning, anonymisation, mining, analysis, and visualisation so that the vast amount of educational data is comprehensible and ethically utilisable by educators or instructors to obtain the advantages and benefits that LA can bring to the educational scene. These include the potential to increase learning experiences and reduce dropout rates. In this chapter, we shed light on OER repositories, LA, and LA dashboards and present an implementation of a research-driven LA dashboard for displaying OER and their repositories that allows the visualisation of educational data in an understandable way for both educators and learners. Moreover, we present an LA dashboard

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for displaying OER that shows information about the existing German OER repositories as part of our EduArc project located in Germany. The LA dashboard consists of multiple adopted indicators and metrics such as the number of reading sessions, duration of reading sessions, number of reading interruptions, number of learning activities, student attendance, and student grades. The details of the research methodology, including a literature review to create this dashboard, as well as the display items of the dashboard are presented and further elaborated.

1 Introduction

Nowadays, with an abundance of data and information that can be harvested from online or offline learning environments, educators or instructors in higher education institutions typically face several challenges before such data can be utilised to improve the teaching and learning processes. Several steps are required until the data can be deployed, including storing, analysing, and anonymising. With a better understanding of such data and how it can be used to improve education, problems need to be forecasted and detected before they arise by taking the relevant measures (and if acted accordingly) (Hlosta et al., 2017; Waddington et al., 2014). With the upsurge of this data, a vast increase in Open Educational Resources (OER) has also been seen in recent years as many initiatives have been created to share, reuse, and standardise online materials (Sinclair et al., 2013). To tackle these challenges, Learning Analytics (LA) plays a significant role in making the data comprehensible. LA consists of miscellaneous steps that include data harvesting, data storing, data cleaning, data anonymisation, data mining, data analysis, and data visualisation (Drachsler & Greller, 2016).

LA is a relatively young field of research and first appeared around 2010 (Call for Papers of the 1st International Conference on Learning Analytics Knowledge (LAK2011) 2011). It utilises an evidence-based approach and practice for analysing and understanding data to support and improve the complexities of both, the learning and teaching processes. LA is defined as “the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs” (Call for Papers of the 1st International Conference on Learning Analytics Knowledge (LAK2011) 2011). In its early stages, organisations such as Society for Learning Analytics Research (SoLAR) and the International Educational Data Mining Society were founded to steer the research community towards data analytics and data mining in education (Siemens, 2013). As a result, LA caught the attention of educational institutions, especially those involved in distance higher education (e.g., Open Universities). This interest stems from the need to improve learning and teaching by moving towards personalisation and customisation to answer the challenges of delivering distance education to large cohorts of online students.

Fostering LA is no easy task. One of the challenges is that LA is a very data-intensive field. The technical development does not allow the web-based data volumes to be processed at sufficient speed, as special hardware requirements are necessary. Until a few years ago, only large data centres could deal with this. Since then, the field and the application of LA in the educational domain have been growing steadily (Ebner & Markus., 2018). With the rise of more capable processors and architectures that allow for the processing of large amounts of data in a reasonable time, scientists around the globe are attempting to make use of the vast amount of information and utilise it for the advantages and benefits that LA can bring to the educational scene (Greller & Drachsler, 2012).

The aim of this chapter is to shed light on the OER repositories, LA, and LA dashboards and present an implementation of a research-driven LA dashboard for displaying OER and their repositories that allows the visualisation of educational data in an understandable way for both educators and learners. This chapter is divided as follows. Section 2 presents an overview of the OER, the problems, and challenges. Section 3 presents our proposed Learning Analytics Dashboard (LAD), the methodology, indicators, and components. Finally, in Sect. 4, we present the conclusion, future work, and limitations of this work.

2 An Overview of Open Educational Resources (OER)

In today's world, education has transformed from purely face-to-face learning into an additional, hybrid way of learning, i.e., blended learning, which is a combination of face-to-face learning (for example, in a classroom or university setting) and online learning via the use of digital technologies. This transformation has been a result of the increasing necessity for learners to be flexible and mobile when undertaking their education due to work and other commitments, as well as the technologies becoming better and more advanced, so that online education is often successful for an increasingly large number of individuals. Nowadays, the ease of access to information and knowledge makes it possible for a large majority to obtain quality education anytime and anywhere around the globe. This is the reason why online learning resources are rapidly increasing in number and size, including those that were previously known as learning objects (LOs) and reusable learning objects (RLOs). Currently, there are plenty of OER repositories that provide educational resources to teachers and students. It is essential to have a platform that provides information on the current state of the Open Educational Resources (OER) in order to keep educators informed (Sinclair et al., 2013).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines OER as learning and teaching materials in any form that either reside in the public domain or under an open copyright licence and that can be shared, adapted, and reused with no or limited restrictions (Scientific and Cultural Organization (UNESCO) xxxx). UNESCO is a branch of the UN agency and has created a dedicated OER programme. In 2002, UNESCO organised a forum where they first introduced the term "Open Education Resource". UNESCO emphasises the free and easy access to high-quality content for every individual, including those in minority and disadvantaged groups. UNESCO believes that universal access to information through high-quality education contributes to peace, sustainable social and economic development, and intercultural dialogue. OER provide a strategic opportunity to improve the quality of learning and knowledge sharing as well as policy dialogue, knowledge-sharing, and capacity-building globally.

2.1 OER Mapping Problems and Challenges

In our research study, we harvested the data mostly from the German OER repositories Econis,[1] OpenClipArt,[2] UniWeimar,[3] ZOERR,[4] Lecture2Go,[5] and HOOU.[6] We encountered a number of problems and challenges while analysing the data. Specifically, the received data required to be organised, prepared, and planned to present it in the way that the learning resource was intended to be utilised. We,

[1] https://www.econbiz.de.

[2] https://openclipart.org/.

[3] https://e-pub.uni-weimar.de/.

[4] https://uni-tuebingen.oerbw.de/.

[5] https://lecture2go.uni-hamburg.de.

[6] https://www.hoou.de.

therefore, decided that in this situation, an LA dashboard would be helpful for users to organise and visualise the large amounts of learning resources appropriately. Each OER is tagged with metadata and, hence, a tool was needed to enable the exploration of these resources as well as to search and locate them.

To analyse the data and explore which metadata elements could be used for our LAD (presented in Sect. 3), we created a python script. After narrowing down the number of elements, we investigated what information is stored in the remainder of the fields. The metadata elements include URL, title, description, language, contribute, copyright and other restrictions, location, source repository, datetime, catalogue entry, keywords, generated subjects, meta-metadata, classification, learning resource type, technical, and abstract. A total of 17 metadata elements are reported in the dataset. There are 14 similar metadata fields that are present in all six repositories. While the “classification” metadata element is present throughout, it is actually empty in every single instance. On the other hand, the “meta-metadata” element has the same content as the “contribute” field throughout. The “catalogue entry” has non-empty values only in the Econis dataset. As for the remaining metadata elements, “abstract” is found only at UniWeimar and Econis including the data. “Technical” is present with the entries in four of the datasets. “Learning resource type” is found in four of the datasets along with the entries.

After cleaning and removing the non-similar metadata fields, 14 metadata fields remained, *title, description, location, source repository, datetime, abstract, learning and learning resource type* (contain single values), *Keywords, URL and language* (arrays containing multiple values), *Catalogue entry, copyright and other restrictions, technical, and contribute* (complex data structures of arrays and nested keys and values).

The “contribute” metadata element contains information about the authors, publishers, and providers of the resource. The “catalogue” entry contains information about the ID of the resource in a catalogue, such as the International Standard Book Number (ISBN) or Online Computer Library Center (OCLC). “Copyright and other restrictions” contains information on the intellectual property restrictions. The “technical” element contains information on the format of the resource and its size.

To tackle the challenges and successfully present the information in a meaningful manner, we developed an LA dashboard for displaying OER that shows information about the existing German OER repositories as part of our EduArc project located in Germany (presented in Sect. 3).

3 Our Proposed Learning Analytics Dashboard (LAD)

This section presents a short overview of the Learning Analytics Dashboards (LAD), metrics, and indicators created in our research team as part of the EduArc project. Typically, LA applications collect data from their interactions with the system resources. To make sense of these captured data, they need to be categorised in a corresponding unit of measurement. These units of measurement are referred to as metrics (Ahmad et al., 2022).

Our LAD consists of multiple adopted indicators (see Fig. 1 below). Metrics are used to create these indicators (Ahmad et al., 2022). Metrics are measurements of the activities a learner does in a learning environment (Ahmad et al., 2022) (e.g., number of reading sessions, duration of reading sessions, number of reading interruptions (Sadallah et al., 2015), number of learning activities, student attendance, student grades (Ruiz et al., 2016), etc.). An indicator shows if and to what extent a particular concept can be derived from the metrics (e.g., reading analytics, ideal reading material (Sadallah et al., 2015), self-regulation, emotional state (Ruiz et al., 2016), etc.). Therefore, the LAD consists of educational foundations, indicators, metrics, and visualisations.

3.1 Research Methodology

In our literature review, we searched and incorporated the following publication outlets: the Technology Enhanced Learning (TEL), the Learning Analytics and Knowledge Conference (LAK) series since 2011, the Journal of Learning Analytics (JLA), the European Conference for Technology Enhanced Learning (ECTEL) since 2012, and IEEE Transactions on Learning Technologies related to the focus of this study.

To create our LAD for displaying OER, we harvested 170 publications. From this selection of publications, we first evaluated the abstracts and excluded theory and policy papers, which are irrelevant for this study. We further excluded papers that had no specific LA concept or any information relating to data visualisation. We ended up with 126 articles, which were read in full by the research team. Finally, we gathered 153 indicators in total as a sum derived from these 126 articles. We used OpenLAIR to search for relevant indicators for our dashboard. It is a Learning Analytics Indicator Repository that helps practitioners and educational researchers make informed decisions about selecting LA indicators for their course design or LAD (Ahmad et al., 2022).

Fig. 1 Our Learning Analytics Dashboard (LAD)

We selected 33 indicators from our extensive list of 153 indicators for our study because the data we harvested from OER repositories are limited to only such information on those OER (presented in Sect. 2.1). Subsequently, we further removed the indicators that focused on user behaviour and interaction because the OER repositories usually do not track user behaviour and interaction and also due to the General Data Protection Regulation (GDPR) (Voigt & Bussche, 2017). Eventually, we were left with 13 indicators in total, as follows:

1. Clickstream analysis (Park et al., 2017)
2. Keystroke analytics (Casey, 2017)
3. Resource usage awareness (Santos et al., 2013)
4. Curriculum/Resource usage (Ferguson, 2012)
5. Clustering/Distribution (Bogarín et al., 2014)
6. Engagement and disengagement (Feild et al., 2018; Papoušek et al., 2016)
7. Performance (resource/user) (Agnihotri et al., 2017; Aljohani et al., 2019; Iandoli et al., 2014; Park & Jo, 2015; Syed et al., 2019)
8. Word count (Purday, 2009; Zancanaro et al., 2015)
9. Ideal resources (Sadallah et al., 2015)
10. Long term engagement (Zhu et al., 2016)
11. Authors' self-reflection (Schumacher & Ifenthaler, 2018)
12. Licence distribution (Europe PMC Consortium, 2015)
13. Language distribution (Kostas Vogias Giannis Stoitsis & Ilias Hatzakis, xxxx; OpenDOAR. xxxx)

The selection of these 13 indicators was based on our project requirements, scope, and nature of the OER datasets. We further harvested the metrics or measurements for each indicator. To implement these indicators, we needed to take their metrics into consideration in the initial stages of the development of our LAD. These 13 selected indicators were examined further and adapted to our project use case. Our proposed dashboard consists of 16 indicators inspired by the work of the 13 listed and cited indicators above.

3.2 Our dashboard's Indicators

Our proposed dashboard includes 16 indicators or visualisations in total. To organise these indicators, we divided our dashboard into three sections - 1. Upper panel, 2. Repositories panel and 3. Keywords distribution panel.

3.2.1 Upper Panel of the LAD

The upper panel of our dashboard includes seven indicators (see Fig. 2). This shows the basic number of resources in total and in each OER repository. This

Fig. 2 Upper panel indicators of the LAD

section aims to give users a quick understanding of the scale and size of the repositories. These seven indicators include Total OER, Total OER in Econis, Total OER in OpenClipArt, Total OER in UniWeimar, Total OER in ZOERR, Total OER in Lecture2Go, and Total OER in HOOU (see Fig. 2). The indicator Total OER is the sum of all the resources harvested and presented in our dashboard. The remaining six indicators show the total number of resources present in each repository.

To make these numbers more appealing and informative, we have developed a sub-indicator that shows the percentage of increase in the number of OER compared to the previous year. This indicator is presented as a green arrow pointing up with the percentage indicating the increase (see Fig. 2). The indicators in this panel were inspired by the works of Park et al. (2017); Casey, 2017; Santos et al., 2013; Ferguson, 2012; Europe PMC Consortium, 2015).

3.2.2 Repositories Panel of the LAD

In this section, we present six interactive indicators in three by two grids and the different distributions of OER repositories in various visualisations. This includes OER licence distribution, OER language distribution, authors and publishers with the most publications, OER distribution by year, and OER distribution by type. The core idea of the repositories panel is to offer the user a combination of an overview based on all resources and the ability to examine in detail each visualisation on the repository level, as studies (Eckerson, 2010; Kirk, 2016) suggest that the user should be offered the ability to filter and receive more detailed information (see Fig. 3).

In Fig. 3, the donut chart is the key visualisation in our LAD. It represents the percentage of resources from each repository. The bigger the donut slice, the higher the number of resources from the given repository. Hovering on a particular slice shows the total number of resources present in the relevant repository. By clicking on a slice or on the legend at the top, the user can change the information

Fig. 3 OER repositories panel of the LAD

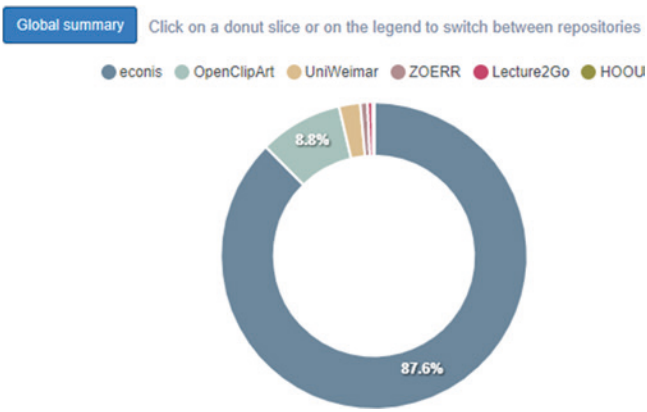

Fig. 4 Repositories distribution Donut chart (key visualisation) of the LAD

source for the whole panel to the repository represented by the slice, thus examining, filtering, and obtaining repository-specific information (see Fig. 4). All five other visualisations are connected to the donut chart. After clicking on a specific slice, the chart will automatically update the data in all five connected visualisations in the panel. The colours inside the panel are changed to that of one of the donut slices as a visual indication that the user is presented with the data for a specific repository. The titles of the visualisations are also changed for clarity. The "Global summary" button at the top left of the donut chart gives the user the opportunity to show the combined information from all repositories. The light blue colour of the "Global summary" button, contrasting to the pastel colours designated for the individual repositories, is used only for the combined information rather than information from a specific repository.

In Fig. 5, a horizontal bar chart represents the distribution of the licences in the UniWeimar repository. It is the result of clicking on the "UniWeimar" slice in the donut chart. It should be noted that, at the most, the top 10 licences will be displayed. The chart's x-axis shows the percentage relative to the number of resources in the given repository. On the y-axis, the licences themselves are displayed. The number of tics/points/labels on the x-axis is reduced for better readability when viewed on a smaller screen. Hovering over a bar reveals a tooltip with the complete name of the licence and the percentage of the resources that are tagged with that licence. All the repositories have a metadata element that indicates if a resource is under copyright or other restriction. Only some of the repositories include more specific information about the types of licence. If available, more detailed information is shown upon request. Otherwise, the number of resources including/not including a licence is shown.

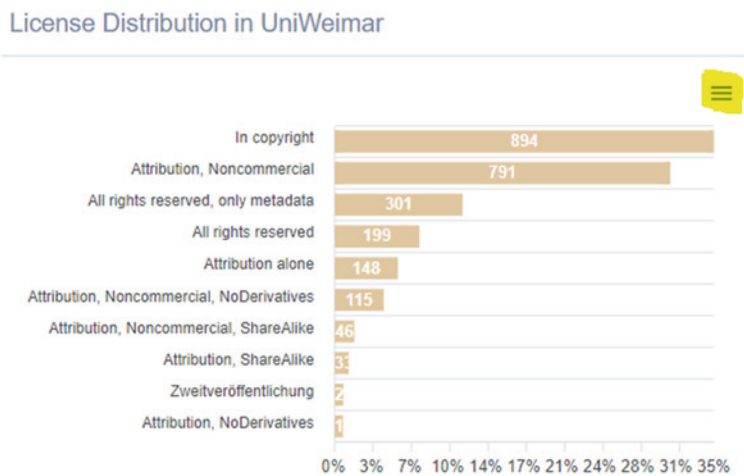

Fig. 5 Licence distribution in UniWeimar, shown in the LAD

Furthermore, to enhance user experience, we also allow users to download a particular visualisation in SVG, PNG, or CSV format for sharing or better understanding. To download a specific indicator, the user must click on the menu button (highlighted in Fig. 5) on the top right to see the download options. The indicator licence distribution is inspired by the works of Santos et al. (2013); Bogarín et al., 2014; Europe PMC Consortium, 2015).

The indicator "language distribution" is visualised with a horizontal bar chart (see Fig. 6). This indicator presents the global summary of OER by language. Figure 6 shows the ten most used languages in the German OER. Approximately 60% of the German OER are presented in German and 30% in English, which is roughly 90% of all the OER. In Fig. 6, the y-axis displays the ten most used languages, while the x-axis shows the percentage of the resources. Each horizontal bar also displays the total number of OER that exist in the relevant repository. Hovering on a bar will display more in-depth information on the used language category. This indicator is inspired by the works of Ferguson (2012); Bogarín et al., 2014; Iandoli et al., 2014; OpenDOAR. xxxx).

Furthermore, Fig. 7 presents the percentage of language distribution in the "UniWeimar" resource repository. This indicator results from clicking on the slice UniWeimar or clicking on the legend UniWeimar in the donut chart presented in Fig. 4.

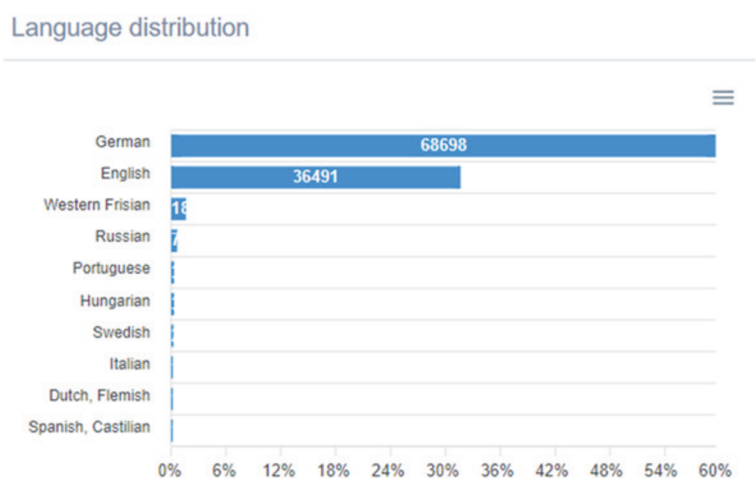

Fig. 6 Global summary of language distribution shown in the LAD

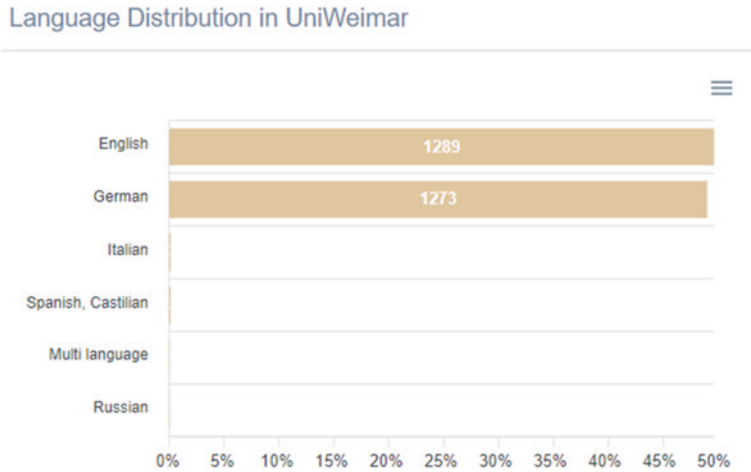

Fig. 7 Language distribution in UniWeimar shown in the LAD

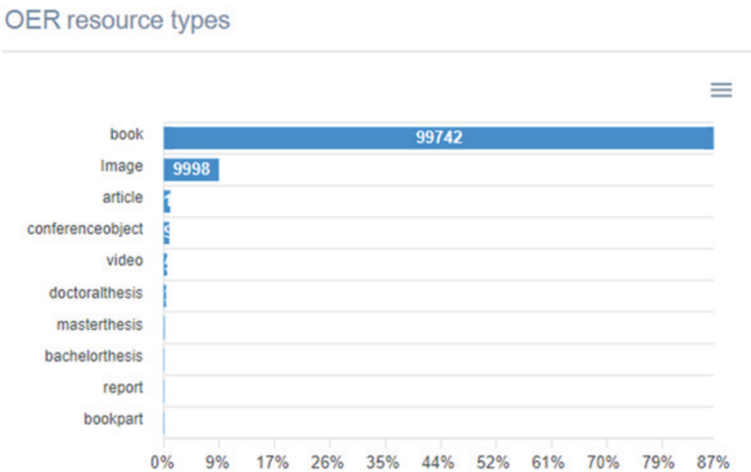

Fig. 8 OER resource types

Figure 8 presents the OER distribution by type. This indicator is visualised with a horizontal bar chart. This indicator represents the global summary of the number of resource types used in the repositories. Like other visualisations in the repositories panel, the light blue colour is always used for the global summary.

The metadata element "learning resource type" is not present in all the harvested repositories. If this is the case, a "No Data" label indicator will be displayed. This indicator is the outcome of the findings of Schumacher and Ifenthaler (2018); OpenDOAR. xxxx; Kostas Vogias Giannis Stoitsis & Ilias Hatzakis, xxxx).

Figure 9 is another similar example that shows the OER resource types distribution in the UniWeimar repository. The colour of the graph is based on the selected repository in the donut slice presented in Fig. 4. The title of the visualisation is also dynamic and changes to the chosen repository. The indicators are shown in Figs. 6, 7, 8, and 9 could be helpful to users as a guide in which repository to search for resources in a given language.

To provide authors and publishers with information on their published resources to reflect their performance, we developed an indicator with two tabs - one is dedicated to authors and one to publishers (see Figs. 10 and 11). Figure 10 presents the ranking in a tabular form, where the top 15 authors with the highest number of published open educational resources are shown. On the other hand, Fig. 11 presents the top 15 publishers with the most published OER. By default, the indicator shows the list of top authors. To see the list of top publishers, one must click on the "publishers with the most publications" tab.

Figures 12 and 13 present the top 15 authors and publishers with the most publications in the repository Econic. Like other visualisations, the information is based on the donut slice selected. Some repositories, such as UniWeimar, Lecture2Go, etc., do not give information about the publishers. If that is the case

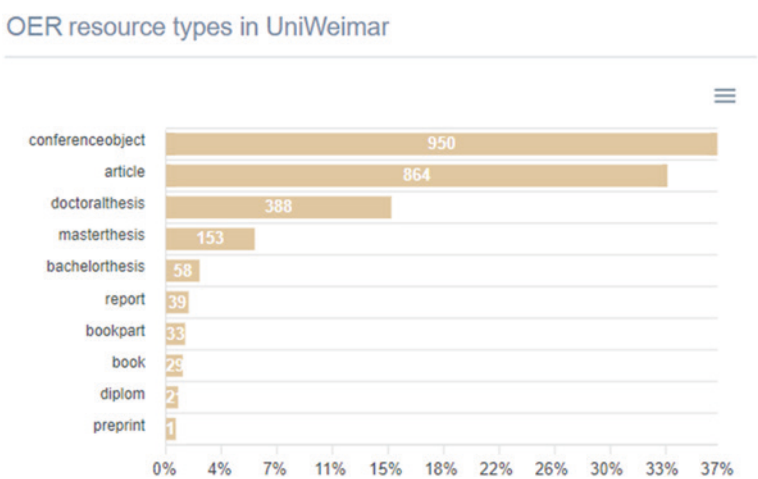

Fig. 9 OER resource types in UniWeimar

Author	#Publications
1. j4p4n	2711
2. liftarn	1383
3. GDJ	1215
4. NicholasJudy567	580
5. hotta	359
6. oksmith	348
7. Rabczuk, Timon	133
8. Arvin61r58	123
9. Manuela.	121
10. Andreas Barth	110
11. Prof. Dr. Matthias Riebisch	93
12. TIGINT	89
13. Dirk Becker	85
14. omercemalarslan	64
15. hund	56

Fig. 10 Authors with the most publications

Publisher	#Publications
1. Duncker & Humblot	2895
2. Gabler	1380
3. Mohr	1258
4. Rand	1236
5. Lang	1190
6. Springer	958
7. Kohlhammer	828
8. Macmillan	743
9. Westdt. Verl.	709
10. Oldenbourg	697
11. Beck	696
12. de Gruyter	642
13. Fischer	613
14. Haupt	608
15. Vandenhoeck & Ruprecht	586

Fig. 11 Publishers with the most publications

with the selected repository, an empty table is displayed to the user. However, no colour indication shows which repository is currently being displayed here. Instead, the tab title at the top is dynamic and changes to the name of the repository selected. These indicators are inspired by the works of Aljohani et al. (2019); Syed et al., 2019; Schumacher & Ifenthaler, 2018).

Authors... | Publishers with the most publications in econis

Authors with the most publications in econis

Author	#Publications
1. Lindbeck, Assar	52
2. Svensson, Lars E. O.	50
3. Lenin, Vladimir Il'i�?	48
4. Wöhe, Günter	43
5. Siebert, Horst	39
6. Weber, Adolf	35
7. Kautsky, Karl	34
8. Spann, Othmar	34
9. Albach, Horst	33
10. Pareto, Vilfredo	32
11. Marx, Karl	30
12. Sombart, Werner	28
13. Dahrendorf, Ralf	24
14. Kirsch, Werner	23
15. Schmölders, Günter	23

Fig. 12 Authors with the most publications in Econic

Authors... | Publishers with the most publications in econis

Publishers with the most publications in econis

Publisher	#Publications
1. Duncker & Humblot	2895
2. Gabler	1380
3. Mohr	1258
4. Rand	1236
5. Lang	1190
6. Springer	958
7. Kohlhammer	828
8. Macmillan	743
9. Westdt. Verl.	709
10. Oldenbourg	697
11. Beck	696
12. de Gruyter	642
13. Fischer	613
14. Haupt	608
15. Vandenhoeck & Ruprecht	586

Fig. 13 Publishers with the most publications in Econic

The final indicator of the "Repositories Panel" of the global summary is a line chart showing the number of resources published each year (see Fig. 14). Again, light blue colour coding is used for the global summary. Not all data points are shown on the x-axis to keep the information more readable, but the user can still

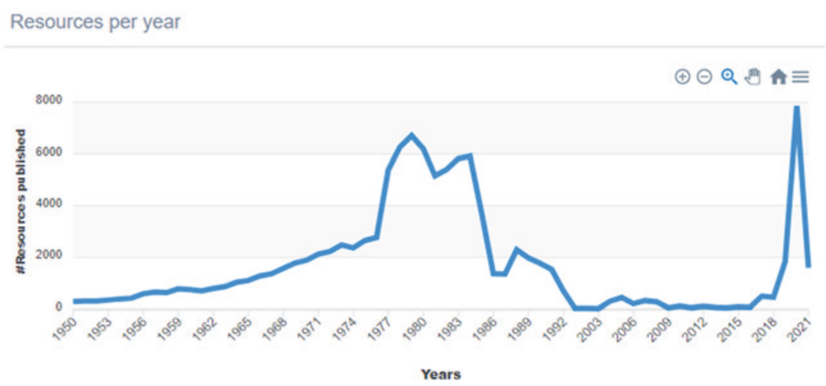

Fig. 14 Resource Distribution by Year shown in the LAD

zoom in and investigate smaller time periods. This indicator is fully interactive, and the user can filter the time frame with the mouse cursor or mouse zoom in and zoom out function. Further, in Fig. 14, there are also several options provided on the top right of the indicator, where the user can also zoom in, zoom out, select, and move the years from left to right or right to left, and the home icon is used for going back to default. The indicator also provides the functionality of downloading the visualisation in the format of the user's choice.

Figure 15 is another similar line chart to the one discussed previously. This indicator shows the number of resources used per year in the Econis repository. The dark grey colour line is used to represent the repository Econis. A dynamic title is used to indicate the selected source repository. This visualisation could be helpful to determine trends in the number of publications published at repository level. This indicator is the result of the analysis of the studies (Bogarín et al., 2014; Feild et al., 2018; Santos et al., 2013; Zhu et al., 2016).

3.2.3. Keywords distribution panel of the LAD.

The third and final section is the keywords distribution panel. In this section, we have included and developed indicators based on the "keywords" metadata element. Unlike the repositories panel, the data here is based on the global summary. The indicators here aim to provide an overview of the keywords used in the harvested repositories. After a review of different methods, we decided to utilise a word cloud for the representation of the keywords in the LAD. In Fig. 16, the word cloud is used to visualise the most used keywords in the selected OER

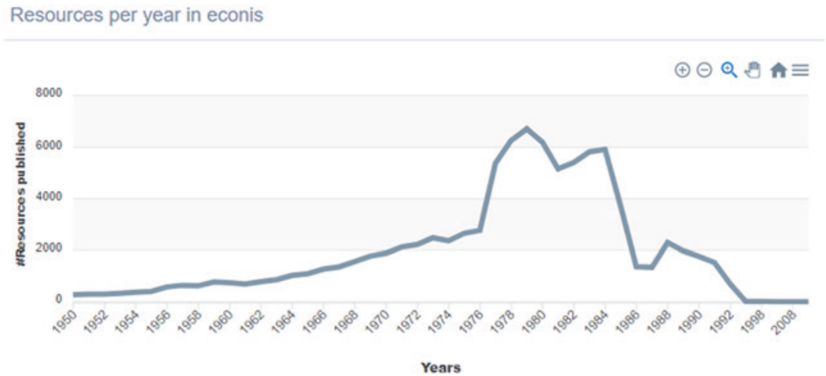

Fig. 15 Resource Distribution in Econis repository by Year shown in the LAD

Fig. 16 A word cloud and a line graph depicting the top keywords shown in the LAD

datasets. Both colour intensity and size are encoded into the visualisation. The bigger and the darker the shade of blue is, and the more central the position of the keyword, the more times this keyword is found as a tag in the keyword metadata element. Hovering over a keyword reveals the exact number of times this keyword is found. In the current implementation, the word cloud shows the top 99 keywords. This was a design decision, so as not to overcomplicate the visualisation and was not due to a technical limitation. It can easily be changed to show a bigger or a smaller number of keywords. Further, we also included and connected a line chart to the word cloud. The line chart is used to show the trend for the usage of a selected keyword. By default, a trend for the most used keyword is shown. In the case depicted here, the line chart shows a trend for the keyword “Deutschland”, which first appeared just once in the year 1912, but since then, the number of uses rose to 1853 times in the year 1979.

Another example can be seen in Fig. 17, which presents the word cloud and a line graph depicting the keyword “Frankreich”. The word cloud provides the functionality of clicking on a keyword to see its trend. By clicking on any of the keywords, the keyword trend is shown on the line graph to the right. The line graph depicts the number of times this keyword was found in publications from a given year. The user can zoom in and investigate a smaller time period. This visualisation could be useful for discovering growing interest in a specific area. This visualisation is the outcome of the results and analysis of the works (Purday, 2009; Sadallah et al., 2015; Zancanaro et al., 2015).

Figure 18 is the last included indicator. It is presented as a stacked horizontal bar chart. Here, the user sees how the top keywords are distributed by location. The 99 keywords from the word cloud are paginated into pages of 10. The user can go through the pages one by one or jump directly to the first or the last page. Our idea is to give the users an overview of where a resource containing a given keyword might be found. The colour-coding of the elements in the chart is not repository-based but based on the order in which the repositories show in the set of keywords.

The proposed dashboard is connected to a dynamic database server. Currently, for the sake of our project scope, we are limited to a small number of repositories, but the tool is flexible enough to manage other newly added repositories. The LAD is accessible from any device, but it is recommended to access it from a desktop or laptop computer.

Fig. 17 A word cloud and a line graph depicting the keyword “Frankreich” shown in the LAD

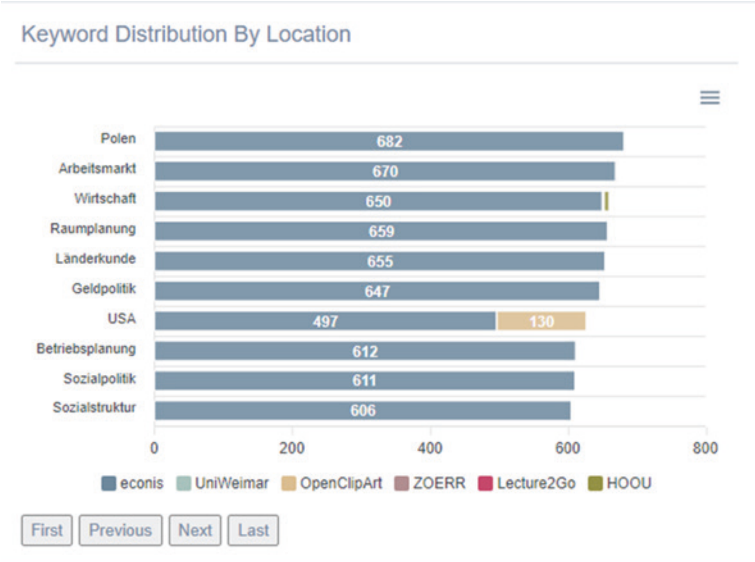

Fig. 18 Keyword distribution by location shown in the LAD

3.3 Technologies Utilised for Creating the LAD

This section discusses the technologies used and the system architecture (see Fig. 19). Our LAD is designed and developed for online access, so we primarily deployed technologies such as HTML, HTML5, Bootstrap, JavaScript, Typescript, Angular, and other server-side languages and services. The utilised technologies and services/processes are divided into three sections - 1. Front-end, 2. Back-end, and 3. Data processing.

3.3.1 Front-End

The main drivers of the front-end are the Typescript-based web applications framework and Angular. According to the 2020 Stack Overflow Developer Survey, Angular is the third most used web framework (www.stackoverflow.com. Stack Overflow, 2020), and it is developed and managed by Google. Our LAD consists of multiple visualisations and indicators. Therefore, we have used two different visualisation libraries. The word cloud visualisation (see Fig. 16) is

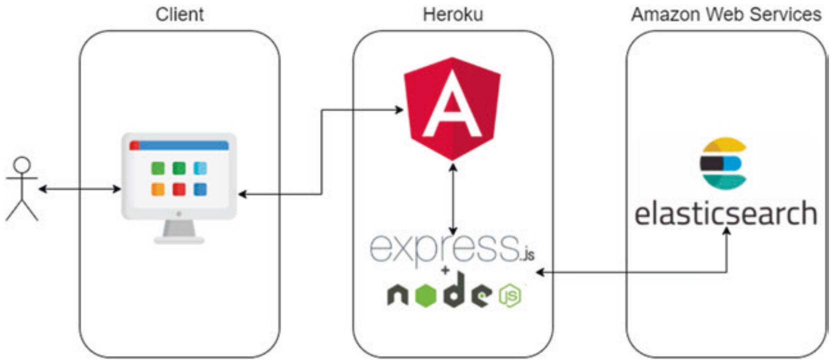

Fig. 19 Our system architecture

created using amCharts,[7] and all other visualisations on the dashboard are constructed using Apex charts.[8]

3.3.2 Back-End

To power the back-end of our LAD, we used NodeJS combined with ExpressJS. NodeJS is an open-source, cross-platform, back-end JavaScript runtime environment, and it was designed as real-time, push-based architectures (Cantelon et al., 2014). NodeJS is a popular server-side language among the software developer community. NodeJS is used by big tech companies such as PayPal, Netflix, eBay, etc.

Angular and NodeJS communicate through the middleware ExpressJS. Once NodeJS receives a request through ExpressJS to send the data that feeds the visualisations to the client-side, it first reaches the caching server. This same event flow can also be seen in our system architecture (see Fig. 19). To effectively analyse and visualise the data, it is necessary to store the data on the database initially. To store our data, we used Elasticsearch; and to host or manage this data, we used Amazon Web Services (AWS). AWS is a secure cloud services platform and a collection of remote computing services that offer computing power,

[7] https://www.amcharts.com/.

[8] https://apexcharts.com/.

database storage, content delivery, and hosting dynamic websites and databases (Amazon, 2015). Elasticsearch is a powerful and scalable open-source engine offering the ability to search and analyse big datasets quickly (Gormley & Tong, 2015). Elasticsearch is used by Wikipedia, Stack Overflow, GitHub, Twitter, etc. Further in Fig. 19, after receiving the raw data from Elasticsearch based on the user/client request, the data is processed by NodeJS. NodeJS sends the processed data as a response back to the Angular client and it is then displayed to the user.

3.3.3 Data Processing

After NodeJS fetches the data from Elasticsearch, it must be processed to be in the proper format for loading onto the charts. Doing the data processing on the back-end saves computational costs on the device of the user. The data we obtained was not ready to use data. We had to analyse and transform the data into understandable data for the indicators. For example, metadata fields like "language" and "copyright and other restrictions" cannot be visualised as they are on our LAD. Therefore, preprocessing and transformation of the data are required. The following is an example of how we solved such issues:

> The "language" metadata field contains the languages tagged on a resource. The format of the values is ISO 639-2/T or a three-letter lowercase code describing each language. To provide the user with the full language name instead of the ISO 639-2/T code, the language value should be filtered after receiving the data from Elasticsearch. We wrote a Python script that scrapes a Wikipedia page[9] and results in a JSON object containing 129 elements with keys that are ISO 639-2/T codes and values that are the full language name. Then, we placed the resulting JSON in a JavaScript file (utils/languages_filter.js) inside the project folder. All the JSON objects that contain language values pass through the filter and update their code values to a full language name.

4 Conclusions, Future Work, and Limitations

In this paper, we proposed an LAD in an attempt to assist students, researchers, and teachers in their interactions with OER by displaying useful information according to the users' needs. This LAD is the outcome of a literature review, in which we identified appropriate indicators and implemented these in our LAD. The research outcomes of various publications inspired this work

[9] https://en.wikipedia.org/wiki/List_of_ISO_639-1_codes.

resulting in our research-driven LAD. The technical implementation of this work is grounded in established technologies that are easily scalable for a significantly larger amount of metadata. Therefore, we plan to extend this dashboard to support a larger number and variety of OER such as MIT Open Courseware, Khan Academy, etc. The technology stack used in this work lends itself as a stepping stone for further development. This study has three main limitations. First, our proposed dashboard may not be the only approach to providing a sophisticated data visualisation. Second, the selected sample of publications was limited since we mostly focused on tool- or LAD-specific papers. Therefore, we recognise that we might have missed indicators and metrics for other purposes to be included in our review and proposed dashboard. Third, there could be a small margin of error in data harvesting due to human lapses or slips.

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