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Leveraging GitLab as a Platform for the Provisioning and Managing of Open Educational Resources in an Open Educational Practices Use Case

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Abstract: Several technologies appeared in the past for the provisioning of OERs (Open Educational Resource). Beside OER-specific infrastructure, the usage of the software repository GitLab has been observed. However, those implementations of OERs with GitLab typically do not leverage all GitLab features that would contribute to OERs. Especially *Issues* as feedback indicator for quality and *merge request* approval rules have not been discussed yet to enable OEPs. These functionalities are presented and then demonstrated in an implemented OEP (Open Educational Practices) use case at NFDI4ING, where experiences were gained. Embedding into a research project and usage of open and existing infrastructure makes the approach sustainable, even from cost perspective. With our work, we highlight which and how GitLab functionalities enable OERs. By doing so, GitLab acts as a technical as well as partially social component of OEPs.

Keywords: Open educational resource (OER); open educational practice (OEP); GitLab; repository; OER infrastructure; OER platform

Nutzung von GitLab als Plattform für die Bereitstellung und Verwaltung von Offenen Lehrmaterialien (OER) in einem Anwendungsfall der Offenen Lernpraktiken (OEP)

Zusammenfassung: OERs werden mittels unterschiedlicher Technologien bereitgestellt. Neben OER-spezifischen Infrastrukturen ist auch die Nutzung des Software-Repositoriums

GitLab für OER zu beobachten. Jedoch zeigt sich in den bestehenden Implementierungen von OERs mit GitLab, dass nicht alle GitLab-Funktionalitäten, die OERs unterstützen, auch genutzt werden. Insbesondere *Issues* als Qualitätsindikator und Feedback sowie Freigaberegeln in *Merge Requests* sind bislang noch nicht diskutiert worden, um OEPs umzusetzen. In diesem Beitrag diskutieren wir diese Funktionalitäten und demonstrieren sie an einem OEP Use Case bei NFDI4ING, in dem wir entsprechende Erfahrungen gesammelt haben. Die Einbettung in ein Forschungsprojekt und die Nutzung offener und bestehender Infrastruktur macht das Vorgehen nachhaltig, auch aus Kostenperspektive. Mit unserer Arbeit zeigen wir auf, wie GitLab-Funktionalitäten OERs ermöglichen. GitLab stellt somit eine technische sowie zum Teil auch eine soziologische Komponente von OEPs dar.

Schlüsselwörter: Open Educational Ressource (OER); Open Educational Practice (OEP); GitLab; Repositorium; OER-Infrastruktur; OER-Plattform

1 Introduction

In the 21st century, creators make their training and learning materials openly available within the OER movement. User can – beyond solely consuming such materials – contribute to such materials, as well reassemble, and redistribute them for their purposes. With the growing momentum of OERs, respective didactical, technical, social, and legal aspects come into consideration. They are referred to as OEPs.

However, this emerges several challenges in OERs and OEPs. Quality of the materials by the creators as well as initial contributors has to be ensured. Costs for the development, provisioning and maintenance of materials have to be considered. Technical platforms with supportive features for OERs have to be chosen. The editing and remixing of materials has to be made simple from a technical perspective, preferably with respective tools on the provisioning platform. Nevertheless, sustainable OERs require technical frameworks as well as legal frameworks and operating/

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business models. These need to be open and interoperable with respect to data, software, and services. Respective information literacy skills need to be conveyed.¹

In this article, we propose the software repository GitLab as platform for OERs and related OEPs. Instead of software code, OERs can be provided there. By doing so, challenges in file management, costs, operation models, contributor management, interoperability, and quality improvement are addressed. Specifically, with regards to quality and collaboration, GitLab *issues* allow users to give and read feedback on the training materials, and *merge request approvals* enable a four-eye principle on contributions to the training. From a legal as well as financial perspective, for institutions already using GitLab, no additional software nor IT approval should be required. Beyond the benefits of GitLab features itself, we document our experiences and practices from the NFDI4ING (National Research Data Infrastructure for the Engineering Science) project. The OERs provided there in GitLab are enhanced together with the community in an OEPs approach.

The article is structured as followed: First, in Chapter 4 the fundamentals of OER and OEP as well as the related topics of quality, FAIR principles, GitLab, are introduced. Next, in Chapter 5 GitLab features are discussed with respect to OER and OEP. Practical insights on this are given in Chapter 6 from an implemented use case. Finally, Chapter 7 concludes this article with a summary and an outlook.

2 Theoretical background and state of the art

2.1 Open educational resources

In the context of education materials, the term OER was initially coined 2002 by the UNESCO² and covers “any educational resources [...] that are openly available for use by educators and students, without an accompanying need to pay royalties or licence fees.”³ Those resources for teaching, learning, and research are open with regards to free access without technical barriers (typically via the internet) and without costs, as well as with an ‘open’ license allowing usage and modification.⁴ Making resources “available in a non-discriminatory way”⁵ “has social, cultural, economic,

technical, and individual dimension”.⁶ Respective licenses are often used from Creative Commons, such as CC 0, CC BY, CC BY-SA, CC BY-ND, although the latter one does not allow modifications and remix of materials (ND: “Non Derivates”⁷) and is therefore questionable for OERs.⁸ Therefore the central aspect of openness has to be considered in a differentiated manner: Openness has various dimensions,⁹ the degree of openness is a spectrum instead of binary states,¹⁰ and openness can inherent addition conditions like giving credit to the initial author.

Wiley characterises OERs in his blog posts by initially four¹¹, later five¹² “R” characteristics with the regards to a legal/license perspective. *Reuse* allows users to use content in their environment. *Revise* enables them to change content (translation is one example mentioned here), and with *Remix* content can be combined with other content for new work. By *Redistribute*, users can share the original, modified, as well as remixed content. *Retain* – added in 2014 – demands that content copies can be created, owned, and controlled.¹³ Using this characterisation, Hilton III et al. applied an ALMS analysis to measure openness in different dimensions and to decide upfront which level of openness to implement. ALMS considers the *Access to editing tools*, the required *Level of expertise required to revise or remix*, if a file is *Meaningfully editable*, and if *Source-file access* is provided.¹⁴

Hylen categorises providers of OERs into the dimension of the provider itself (institutional to community), their scale of operation (small to large), and the number of disciplines covered (single discipline to multidisciplinary).¹⁵ Camilleri et al. mentions the classification of OER types by Marguiles into tools, content, and implementation resources. As tools, content management systems, social software (like wikis), development tools, and learning management tools are mentioned. The user interaction with OERs ranges from access to collaborative contribution,¹⁶ hence the openness (license, technically etc.) should allow remixing. Due to this consumption and interaction with OERs, the aspect of sustainability comes into play. Sustainability of OERs has dimensions of funding, technical, and content,¹⁷ as well as the embedding

1 Adil et al. (2024) 15.

2 UNESCO (2002) 24.

3 UNESCO et al. (2015) 5.

4 Atkins et al. (2007) 4, Hylen (2006) 1, Tuomi (2013) 62.

5 Tuomi (2013) 61.

6 Ibid. 60.

7 License text: <https://creativecommons.org/licenses/by-nd/4.0/>.

8 Bliss and Smith (2017).

9 Tuomi (2013) 60.

10 Hilton III et al. (2010) 4.

11 Wiley (2009).

12 Wiley (2014).

13 Ibid.

14 Hilton III et al. (2010) 8.

15 Hylen (2006) 3.

16 Tuomi (2013) 67.

17 Downes (2007) 34–39.

of OER initiatives into structures and programs.¹⁸ Especially the costs for OER development, provisioning and maintenance can become significant; the openness on user side as cost-free access in the sense of ‘open’ does not necessarily mean cost-free on the creator side.¹⁹ Processes and life cycle of OERs are described by Camilleri et al.²⁰

2.2 Open educational practices

For OERs, initially mentioned as (open) “courseware”, in 2002 the UNESCO raised the discussion question “What infrastructure requirements must be met in order to make courseware globally viable?”.²¹ The UNESCO recommends considering technology, organisation, and policy. Technology encompasses hardware and (preferably technology-agnostic, integrated, and usable) software, which provide connectivity and follow respective standards. From an organisation point of view, standards should be considered, training and technical competencies imparted, and user groups addressed. Policies covers the consideration of business models as well as the usage of open frameworks and tools.²²

With the dissemination and institutionalisation of OERs, such factors – now named as OEPs – gained more attention over time. OEP can be seen as the second of two phases, where in the first phase OERs are shared, whereas in a subsequent second phase these are handled within open learning architectures, quality improvement through external validation, and institution’s value proposition.²³

Therefore the following is put forward as a general definition: “Open Educational Practices (OEP) are the use of open educational resources with the aim to improve quality of educational processes and innovate educational environments.”²⁴

The focus is thereby not on the resource itself, but on practices around creating and using it, acting as a holistic approach.²⁵ OER materials and infrastructures are extended with OEPs by practices on dealing with them. This can include collaborative scenarios, models, formats, and general conditions, where stakeholders use, create, and develop OERs.²⁶

The same way Andrade et al.²⁷ define OEPs as activities and practices that support learning with OERs and (re)usage of them along the community. In addition to the definition quoted before, main characteristic of OEPs is the involvement and collaboration with others on OERs.²⁸ Also Ehlers and Conole highlights the “collaboration between content creators and users” and “interplay between stakeholders, organisational elements and resources”²⁹ to repurpose OERs. Missing ICT skills, missing support and lacking incentives were challenges identified in the context of OERs.³⁰

OEPs cover tools and resources for OER creation and use, technology for hosting and management, and contextual factors.³¹ The Openness of Educational Practices can be considered in four dimensions: social (open: participative, community), technical (open: non-proprietary file formats), legal (open: public domain / CC BY license), and financial (open: free, no registration, affordable).³² In 2014, this was adjusted to five dimensions: technical, legal, cultural, pedagogical, financial.³³

As technical foundations and structures for OER and OEP, the German Federal Ministry of Education and Research (BMBF)³⁴ mentions technical environments with modular and usable elements, data standards and findability including metadata, mechanisms for quality, and future-ready infrastructures with open-source software and security and source code availability.

As the quality and quality assurance for OERs and in OEPs is one main discussion point, the quality aspect will be introduced in the following separate section.

2.3 Quality of OERs

With the provisioning of OERs, this raised the aspect of quality assessment and quality assurance. Assuring and controlling quality is one of the challenges and issues within OERs.³⁵ This can be challenging especially due to the dynamic development process with external contributions and encouraged redistribution.³⁶ Scepticism towards open

¹⁸ D’Antoni (2009) 7.

¹⁹ Downes (2007) 32, 34 f.

²⁰ Camilleri et al. (2014) fig. 6.

²¹ UNESCO (2002) 19.

²² Ibid.

²³ Andrade et al. (2011) 12, Camilleri et al. (2014) 12 f.

²⁴ Ehlers and Conole (2010) 3 f.

²⁵ Ibid. 3.

²⁶ Federal Ministry of Education and Research (BMBF) (2022) 10.

²⁷ Andrade et al. (2011) 12 f.

²⁸ Camilleri et al. (2014) 28.

²⁹ Ehlers and Conole (2010) 4.

³⁰ Adil et al. (2024) 14.

³¹ Ehlers and Conole (2010) 2.

³² Hodgkinson-Williams and Gray (2009) 104–11, 113.

³³ Cronin and MacLaren (2018) 131 f.

³⁴ The Federal Ministry of Education and Research (German: Bundesministerium für Bildung und Forschung (BMBF)) has been renamed in 2025 to *Federal Ministry of Research, Technology and Space*

³⁵ Hylen (2006) 7 f., D’Antoni (2009) 7, Al Abri und Dabbagh (2018) 94, Adil et al. (2024) 12 f.

³⁶ Lübken et al. (2023) 139.

and free resources is observed.³⁷ Different formats and various platforms can impact quality assessment as well.³⁸

Quality becomes relevant when using materials for teaching/learning as well as when contributing to it. This creates the “dilemma”³⁹ – one could see it as chicken-or-the-egg dilemma – that users would like to know quality of specific OER materials upfront but are required to take a look into the materials to determine the quality. In addition to the creator of OERs, users are jointly responsible for quality as well due to two considerations: First, despite the correctness of information (that can be ‘right’ or ‘wrong’), quality can be subjective and depending on the context (for the respective purpose, ‘fit-for-usage’); and second, within the open design there is at least for educators the responsibility to check learning materials and to potentially provide feedback.⁴⁰ Another quality-related issue in the context of OERs is that if a resource M is reused/remixed in a different resource N, a later correction/adjustment of M will not automatically be reflected in N.⁴¹

The quality improvement of shared OERs is an aspect of OEPs.⁴² Or expressed with the words by Ehlers and Conole: “educational quality [...] is a characteristic of educational practice, and not (only) [of, author’s note] an educational resource”.⁴³

To determine quality of OERs, criteria for quality of OERs have to be defined first. Overall, various quality criteria exist.⁴⁴ Oliveira et al. identified quality attributes for OERs based on literature review. They apply to the content as well as to the software used. Content is characterised by motivation understandability, interactivity etc. as well as metadata and license; for the software aspects like compatibility (interoperability), security, maintainability, and portability are discussed.⁴⁵ The Instrument for Quality Assurance of OER (IQOER)⁴⁶ is a list of 37 preliminary items. Main focus is on the OER content. IQOER states how to measure and what to consider with regards to quality of OERs, but not how to implement this. The result is visualised in a one-dimensional five step classification. Romero-Pelaez et al. propose six quality metrics for OERs (availability on the web, open license, use metadata standards, quality meta-

data, semantic representation and annotation, services creation for consumption), that are each fulfilled or not within a five-level maturity model. Objective is to prepare OERs for the emergent technologies of natural language processing and semantic web technologies.⁴⁷ Safiulina et al.⁴⁸ propose and evaluate a quality assessment for OERs. Based on five KPIs,⁴⁹ they mention four levels within each KPI. For KPI-3 Technical Characteristics, they demand i. Reliability and Adaptability, ii. Accessibility and Compatibility, iii. Customization and Flexibility, as well as iv. Performance and Speed.⁵⁰

This overview of criteria demonstrates that quality of OERs has multiple facets, ranging from the content representation and didactics to its metadata as well as the technical provisioning.

To assess and/or ensure quality of OERs, several approaches are discussed. Peer-reviews are well-known from academia.⁵¹ Peer reviews can be conducted as in scientific publications, while internal quality checks are not open other users. The provider’s institution can serve as a (vague) indicator for quality, since bad quality would threaten the institution’s reputation.⁵² Rating systems for OERs are another potential quality indicator discussed in literature.⁵³ Al Abri and Dabbagh mention Yin and Fan’s approach to continuously improve OERs in a collaborative network.⁵⁴

With the several challenges and root causes for quality in OERs, these need to be addressed within OEPs.

2.4 FAIR principles

In RDM, the *FAIR Principles* by Wilkinson et al.⁵⁵ emerged, which aims to make scholarly digital object *findable, accessible, interoperable*, and therefore finally *reusable*. This is described in four *foundational principles*, which are split into a subset of in total fifteen more detailed *guiding principles*. The FAIR Principles foster reuse, but do not assess the (content-wise) quality of the data. OERs are considered as “complementary”⁵⁶ to the FAIR Principles.

37 Al Abri und Dabbagh (2018) 94.

38 Adil et al. (2024) 15.

39 Ehlers und Conole (2010) 6.

40 Ibid. 5, UNESCO et al. (2015) 12.

41 Al Abri und Dabbagh (2018) 94 f.

42 Andrade et al. (2011) 12, Camilleri et al. (2014) 27.

43 Ehlers und Conole (2010) 6.

44 Rf. e.g., Zawacki-Richter and Mayrberger (2017) and Mayrberger et al. (2018) for a comparison overview.

45 Oliveira et al. (2021) 4–7.

46 Lübken et al. (2023).

47 Romero-Pelaez et al. (2019) 1117 f.

48 Safiulina et al. (2025) 274 f.

49 The KPIs by Serrat et al. (2024) are: KPI-1. Content (C), KPI-2. Didactics (D), KPI-3. Technical Characteristics (TC), KPI-4. Accessibility (A), KPI-5. Inclusive communication (IC).

50 Safiulina et al. (2025).

51 Hylen (2006) 7 f., Al Abri und Dabbagh (2018) 93 f., Adil et al. (2024) 12 f.

52 Hylen (2006) 7.

53 Al Abri und Dabbagh (2018) 94, Adil et al. (2024) 12 f.

54 Yin and Fan (2011) 184 mentioned by Al Abri und Dabbagh (2018) 84.

55 Wilkinson et al. (2016).

56 European Commission et al. (2020) 18.

FAIRness for training materials has already been recognised in the literature. Garcia et al. demand ten rules: 1. Sharing training materials online, 2. providing a proper (metadata) description, 3. applying a unique identifier, 4. register training materials online, 5. define access rules, 6. use interoperable format, making trainings reusable by licensing and metadata for 7. trainers and 8. Trainees, 9. making trainings available for contributors, 10. keeping training materials up-to-date.⁵⁷ This makes training materials findable (2–4), accessible (5), interoperable (6), and reusable (7–10).

2.5 OER platforms and GitLab

Motivated by the right for education for everyone, in 2012, the UNESCO published their declaration on OERs. It includes ten recommendations for actions, including “enabling environments for use of Information and Communications Technologies (ICT)”.⁵⁸ The need for such ICT infrastructure has been recognized internationally.⁵⁹ As examples, UNESCO et al.⁶⁰ mentions wikis and learning management systems, including moodle⁶¹ among others. According to Schröder,⁶² higher education universities in their decentralised structure are already offering in general such platforms for OERs. However, this does not include learning management systems like moodle, which do not have the goal of providing educational resources openly, i.e., publicly accessible under free license. To be capable to deal with future challenges and to ensure OER sustainability in the long-term, a respective OER infrastructure needs to be flexible and extendable.⁶³

GitLab⁶⁴ is a software repository and versioning management platform. It leverages git for distributed software management. This underlying git provides the version mechanism, where for each file version a ‘snapshot’ is created, that is provided via a central repository for decentralise collaboration while ensuring integrity of the files.⁶⁵ GitLab’s version ‘Community Edition’ is open source,⁶⁶

which does not apply to their competitor GitHub⁶⁷ as proprietary software.⁶⁸ Typical features of GitLab as well as GitHub are source code management with versioning, code pipelines for software delivery, issue tracking and more.

GitLab (or GitHub) for training materials and OERs has been recognised before. Lechtenbörger⁶⁹ mentions Git in the context of the *Ljubljana OER Action Plan*⁷⁰ as a cost-effective and sustainable solution to share OERs. Dichev et al. raise the idea in general of using a software repository like GitHub for OERs and highlights especially the openness compared to closed/proprietary learning management systems: “Several authors suggested the social code-sharing network GitHub as a tool for managing the OER production process. The idea is to use GitHub with open educational content as the ‘code’ to share.”⁷¹

Providing OERs with their open nature in a proprietary LMS is “[p]aradoxically”,⁷² whereas GitLab/GitHub are expected to be capable to address certain challenges in OERs and therefore could be a replacement for ‘closed’ systems.⁷³ A growing trend is observed of using text-based formats within such repositories.⁷⁴

However, according to Schröder⁷⁵ only a few cases are described for leveraging version control systems (like GitHub or GitLab) for collaborative learning. The following implementations of OERs on GitLab/GitHub are described in the academic literature. Dürkop et al.⁷⁶ uses GitLab with Markdown files for static websites and in combination with GitBook. Zagalsky et al.⁷⁷ investigate GitHub for learning and teaching, where students can provide submissions, and where a teacher can provide materials. They describe the options to launch websites via *GitHub Pages* and to suggest improvements via *Pull Requests*.

Based on existing literature, GitLab has been considered because its general openness, the versioning and transparency in the commit history, the options for contributing via pull requests and merges, and the forking feature for independent copies.⁷⁸ Reviews and quality assurance

⁵⁷ Garcia et al. (2020) 3–7.

⁵⁸ UNESCO (2012) 2.

⁵⁹ Butcher (2011) 28 f.

⁶⁰ UNESCO et al. (2015) 58.

⁶¹ <https://moodle.org/?lang=en>.

⁶² Schröder (2023) 243.

⁶³ Adil et al. (2024) 15.

⁶⁴ <https://about.gitlab.com/>.

⁶⁵ git-scm.com and Chacon (2025).

⁶⁶ Sijbrandij (2016), Repository code available at <https://gitlab.com/gitlab-org/gitlab>.

⁶⁷ <https://github.com/>.

⁶⁸ Dürkop et al. (2018) 2, Lechtenbörger (2019) 108.

⁶⁹ Lechtenbörger (2019).

⁷⁰ UNESCO (2017).

⁷¹ Dichev et al. (2015) 122.

⁷² Ibid.

⁷³ Ibid. 123 f.

⁷⁴ Garcia et al. (2020) 5.

⁷⁵ Schröder (2023) 244 f.

⁷⁶ Dürkop et al. (2018).

⁷⁷ Zagalsky et al. (2015).

⁷⁸ Ibid. 1908 f., Dürkop et al. (2018) 4, 6 f., Lechtenbörger (2019) 103, Garcia et al. (2020) 5, Schröder and Pfänder (2020) 338 f., Schröder (2023) 249.

can be conducted within merge requests.⁷⁹ The platform GitHub is seen as “relatively easy to use and to administer”.⁸⁰ However, the quality assurance in particular as well as OEPs with GitLab (or alternatively GitHub) have not been mentioned yet in the previous examples from the literature.

3 GitLab as platform for OERs and OEPs

Based on the characteristics and requirements of OERs and OEPs described before in Chapter 4, GitLab and its features will be evaluated regarding addressing these. Although the alternative GitHub, gitea, forgejo and others provides similar features, the focus is here on GitLab, as its Community Edition is open source⁸¹ and as GitLab is widespread in education. GitLab states that internationally more than 1000 educational institutions are part of their Education Program, where GitLab is provided for such institutions, esp. universities.⁸² In the following, the infrastructure itself, the file provisioning, collaboration mechanisms, and quality assurance are discussed.

3.1 Open and standardised/established infrastructure

For software management, code repositories like GitLab or GitHub are the de-facto standard, serving as established and standardised infrastructure. As such, it goes along with the need formulated by Atkins et al. “As digital OER content grows, so will the need for systematic reliable infrastructure for curating and preserving access.”⁸³ Interoperability and openness provides the chance to adapt to future technologies and requirements, especially since there will unlikely be only one standard for OERs.⁸⁴

Leveraging an existing GitLab instance at a university for OERs provides two benefits: Regarding the cost aspect (rf. sustainability in Downes⁸⁵) no additional direct costs appear for an existing GitLab infrastructure, esp. in com-

parison with procuring a separate tool for OERs. Dürkop et al.⁸⁶ mentions that an existing tool like GitLab usually has undergone testing and evaluation, e.g., regarding legal and data privacy aspects, which would be required again for a newly introduced tool. Moreover, as a platform itself, an existing GitLab instance is therefore already embedded into the organisation (aspect sustainability/organisation).

GitLab offers a user management with authentication and authorisation. Users can be assigned to projects in repositories in different roles (e.g., guest, developer, owner) with respective permissions. Nevertheless, repositories with visibility set to public can be accessed without registration. This allows users to access OER content without barriers for registration, making it openly available.

3.2 Storage, provisioning, and access

GitLab provides storage for files in a folder structure. It is designed for text-based files, whereas binary files (e.g., images, audio) are possible as well. For large files (e.g., videos), there is the Large File Storage⁸⁷ extension.

As repository, GitLab versions provided files. This aligns with the requirement of IQOER “30. It is possible to access all previous content at any time”⁸⁸ and the versioning of OER content in general.⁸⁹ Changes are indicated in the *Commit* history.⁹⁰ Access is not only possible to the published/rendered training, but to the underlying files for creation as well. This fulfils the aspect of the ALMS-Analysis “S” (Source-file access).⁹¹

Initially choosing PDF as file format, Atkins et al.⁹² re-examined that choice towards an open and text-based file format. E.g., html, Markdown, or rendering as GitLab Pages etc. serve as such open files for OERs. Open, text-based file formats provide several benefits. In versioning, for text-based files changes can be indicated row by row,⁹³ whereas changed binary files are considered as a completely new file with each change. This makes changes in text-based files

⁷⁹ Dürkop et al. (2018) 6 f.

⁸⁰ Zagalsky et al. (2015).

⁸¹ <https://gitlab.com/gitlab-org/gitlab>, <https://about.gitlab.com/blog/gitlab-is-open-core-github-is-closed-source/>.

⁸² <https://about.gitlab.com/solutions/education/>.

⁸³ Atkins et al. (2007) 25.

⁸⁴ Ibid. 26.

⁸⁵ Downes (2007) 34 f.

⁸⁶ Dürkop et al. (2018) 2.

⁸⁷ <https://docs.gitlab.com/topics/git/lfs/>.

⁸⁸ Lübben et al. (2023) 155.

⁸⁹ Schröder (2023) 247–50, other suggested approaches by Schröder (2023) 252–57 are to integrate version information into the metadata or the OER document itself, or to register DOIs for the overall training as well as certain versions.

⁹⁰ https://docs.gitlab.com/user/project/repository/files/git_history/.

⁹¹ Hilton III et al. (2010) 8.

⁹² Atkins et al. (2007) 26 f.

⁹³ *Diff*: https://docs.gitlab.com/development/merge_request_concepts/diffs/.

more comprehensive compared to binary files and reduces the required amount of storage. In contrast to binary files, text-based files can be edited with GitLab's build-in editor⁹⁴ or WebIDE⁹⁵, which addresses in the ALMS analysis "A" (Access to editing tools).⁹⁶ Especially those text-based file formats are "M" (Meaningfully editable in ALMS analysis).⁹⁷ There are options for the automated conversion to e.g., html and pdf.⁹⁸

By default, GitLab allows to set visibility and access rights. The 'public' option makes stored files (trainings and underlying materials) available for everyone interested, which aligns with the demanded open and free access to OERs; 'internal' repositories for accessible after invitation and might be used for development of OERs before publishing; 'private' repositories are only accessible for the creator. Allowed access can be via GUI and API.⁹⁹ This overall contributes to accessibility as demanded by the FAIR Principle "A".¹⁰⁰

Beside the training data itself, metadata should be provided to give context. A README file is a good practice in GitLab to give first information on the project and repository. GitLab offers to add a license to the repository, although choosing and picking a specific license is the creator's responsibility. Such additional information is displayed in the sidebar.

The FAIR principles require identifiers to make objects findable. The URL of the repository or the training files can serve as unique identifier; however, they are not necessarily persistent, as file names and repository names can be changed. Moreover, such a URL to a file in the repository always points to the latest version. Specific versions can be references with a link to a certain branch and its commit. For OERs and as OEP, this might be the situation when a correction to a previous version which has been cited is done. A workaround to gain a DOI is to publish a 'snapshot' of trainings as stable version in a data repository like e.g., zenodo.¹⁰¹ This can be done by a manual upload or using specific add-on and interfaces.¹⁰²

3.3 Collaboration and contribution

Collaborative software development is the main motivation for git-based software repositories. Certain established patterns can be transferred from there to the collaboration on OERs as OEP. Development is happening in so-called *Branches*¹⁰³ away from the main branch where the latest stable version is published. In the context of collaborative OER development, such branches can serve as 'playground' as well as test system, esp. in scenarios where content is rendered. Where required, branches could be used for different versions of an OER as well. Once work is finalised in a branch, it can be requested to be integrated into the main branch via a *merge request*.¹⁰⁴ Within such merge requests, the proposed changes can be explained and discussed, and rules¹⁰⁵ can be applied. The discussion in merge request can be set to public, fulfilling the goal of making the development transparent. As rules, an approval can be set as required.

For collaborating, external users can be invited to the instance¹⁰⁶ (which is not to be confused with the guest user permission role). A Wiki¹⁰⁷ can serve as introduction, e.g., explanations how to work on materials. Based on *issues* and *milestones*, even the future scope of OERs could be managed in GitLab via Kanban Boards,¹⁰⁸ indicating the reader and potential collaborators future steps.

3.4 Quality assurance and assessment

Quality assurance and assessment as one of the main challenges for OER and OEP can be supported with respective GitLab features as well. Regarding the reputation argument from above, a GitLab instance hosted by an educational institution can be a first indicator for quality. Same applies for real names in commitments as authors. merge requests have already been introduced in the previous section. *Merge request approvals*¹⁰⁹ can be used to implement four eyes' principles, potentially in combination of developers and reviewers, which equals a peer review (which were suggested by Atkins et al.¹¹⁰ and others). Transparent merge

⁹⁴ https://docs.gitlab.com/user/project/repository/web_editor/, https://docs.gitlab.com/user/rich_text_editor/.

⁹⁵ https://docs.gitlab.com/user/project/web_ide/.

⁹⁶ Hilton III et al. (2010).

⁹⁷ Ibid.

⁹⁸ Atkins et al. (2007) 27.

⁹⁹ <https://docs.gitlab.com/api/rest/>, <https://about.gitlab.com/de-de/blog/2024/10/16/what-is-a-rest-api-guide-and-functions/>.

¹⁰⁰ Wilkinson et al. (2016) 4.

¹⁰¹ <https://zenodo.org/>.

¹⁰² For GitHub: <https://docs.github.com/de/repositories/archiving-a-github-repository/referencing-and-citing-content>.

¹⁰³ <https://docs.gitlab.com/user/project/repository/branches/>.

¹⁰⁴ https://docs.gitlab.com/user/project/merge_requests/, https://docs.gitlab.com/development/contributing/merge_request_workflow/.

¹⁰⁵ https://docs.gitlab.com/user/project/merge_requests/approvals/rules/.

¹⁰⁶ https://docs.gitlab.com/administration/external_users/.

¹⁰⁷ <https://docs.gitlab.com/user/project/wiki/>.

¹⁰⁸ <https://docs.gitlab.com/tutorials/kanban/>.

¹⁰⁹ https://docs.gitlab.com/user/project/merge_requests/approvals/.

¹¹⁰ Atkins et al. (2007) 30.

requests make the discussion comprehensive. Transparent quality feedback loop as well as versioning are required to do the issue described by Al Abri and Dabbagh¹¹¹ that later changes in materials are not reflected in other materials build upon the first one.

To collect user feedback and make this visible, *issues*¹¹² as overall comments on the provided files are proposed here. Optionally templates¹¹³ can be prepared to collect predefined groups of feedback (like e.g., corrections and ideas). The idea to use GitLab issues for quality assurance has not been discussed in the literature for OERs yet. The commenting system is somehow similar to the reviews of products in online marketplaces, supporting users/customers to form an opinion beforehand and to provide feedback afterwards. We expect writing an issue as low-entry barrier and less effort way to contribute to the content in a structured and open way, esp. in contrast to providing a full solution like in a merge request. The term *issue* might be misleading in this context, as users are not limited to report corrections, but can provide general feedback, a rating, or ideas for extensions as well. Issues are public by default but can be set to non-public visible in case of e.g., sensitive content or security breaches.

3.5 R's of OERs by Wiley

The demanded 'R's by Wiley¹¹⁴ can be addressed with the proposed approach, mainly technically but socially as well: Reuse is enabled by open file formats and a respective license mentioned in the files. Revise is possible esp. for open file formats with GitLab's build-in editors. By downloading files, they can be remixed. Redistribution can be done in the original repository, in a *mirror* of it,¹¹⁵ or a local downloaded copy. Retain can be achieved by *forking*,¹¹⁶ which means to create a stand-alone copy.

3.6 Accessibility of content

For people with sensorial and motorial disabilities, openness of training materials is determined by its technical accessibility. Most current OERs are limited in their accessi-

bility of the resource as well as the providing website.¹¹⁷ For websites in general and other mobile application interfaces, the WCAG conformity (web content accessibility guidelines) is a recommendation by the W3C (world wide web consortiums) developed in the web accessibility initiative.¹¹⁸ Accessibility is described within the four foundations principles *perceivable*, *operable*, *understandable*, and *robust*, as well as 13 guidelines underneath. For each guideline, success criteria can be tested, evaluating conformity from A (lowest) to AAA (highest). The recommendations are technology-agnostic. The WCAG have been standardised internationally in the norm ISO/IEC 40500:2012¹¹⁹ and are recognised in the norm EN 301 549¹²⁰ for the European Union (EU). Nowadays, barrier-free access to various websites of certain categories is required in the EU under the *Directive on the accessibility of the websites and mobile applications of public sector bodies*¹²¹ and the respective local laws.

For the proposed provisioning of OERs with GitLab, accessibility applies on the levels of the training materials itself, the rendering engine like LiaScript, as well as GitLab as the provisioning platform.

- The creator of training materials is responsible for a respective design that supports accessibility. This includes leveraging features of Markdown. Using the Markdown commands for headlines creates a hierarchical document structure. Tables should be readable row-by-row, and not be used to structure pages. Authors should select colours in a way that text is contrasting with the background and that graphics are colourblind-safe. Text should be written plain instead of in graphic. In Markdown, authors can use features supporting accessibility like the provisioning of textual image descriptions in the alternative text,¹²² and analogous for descriptions of hyperlinks.
- OERs written in LiaScript are rendered, where certain features for accessibility are provided. A navigation panel is created based on the headlines in the document structure. Users can switch to a dark mode for

¹¹¹ Al Abri and Dabbagh (2018).

¹¹² <https://docs.gitlab.com/user/project/issues/>.

¹¹³ https://docs.gitlab.com/user/project/description_templates/#use-the-templates.

¹¹⁴ Wiley (2009) and (2014).

¹¹⁵ <https://docs.gitlab.com/user/project/repository/mirror>.

¹¹⁶ Fork: https://docs.gitlab.com/user/project/repository/forking_workflow/.

¹¹⁷ Navarrete and Luján-Mora (2015) 25.

¹¹⁸ World Wide Web Consortiums (W3C) (2024).

¹¹⁹ <https://www.iso.org/standard/58625.html>, for WCAG 2.0, version with WCAG 2.2 is currently available as draft under development at <https://www.iso.org/standard/91029.html>.

¹²⁰ European Telecommunications Standards Institute (ETSI) et al. (2021).

¹²¹ <https://eur-lex.europa.eu/eli/dir/2016/2102/oj/eng>, English version: <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016L2102>.

¹²² Syntax: `![Alternative text](/path/to/the/image.png "Image Title")` The alternative text should include a description of the image, while the image title is displayed when hovering over the image with the mouse cursor.

less brightness and adjust the font to three different sizes. The site is designed responsive for zooming in. A text-to-speech for audio output is provided as well as an (experimented) translation feature for written text is available. Since LiaScript is extending Markdown's original scope, for such LiaScript-specific elements the accessibility e.g., for standard screen readers has to be considered in particular.

- GitLab reports their conformance with WCAG for various criteria as “supports” or “partially supports”.¹²³ This applies to their Enterprise Edition Premium version 17.0, although other version may slightly vary in scope and therefore accessibility. Moreover, GitLab provides an Accessibility Statement¹²⁴ for their products, conforming to WCAG 2.2 on level AA.

Beyond these features and best practices, a scope for future research is to conduct a WCAG assessment for the proposed provisioning with GitLab (assessments like conducted by Saripudin et al.¹²⁵ or Da Rosa and Motz¹²⁶ for several other OER repositories, although neither LiaScript nor Git(Lab) is covered there).

3.6.1 Skills as requirement

The ALMS analysis considers in aspect “L” the “Level of expertise required to revise or remix”.¹²⁷ Leveraging the introduced GitLab features requires respective skills. It needs to be evaluated in future how far the limited skills¹²⁸ impacts the usage of GitLab by creators for OERs. E.g., issues are simple to operate, but even the GitLab interface might be overwhelming for inexperienced users.

3.6.2 Open points

Didactics are a central point in OERs and OEPs. Nevertheless, they are not addressed by any GitLab feature, but left as responsibility for training creators and consumers. The lack of findability of OERs¹²⁹ is not addressed by the proposed GitLab. Distributed GitLab instances at several uni-

versities might even be contra-productive towards findability. Here existing services like Twillo, OERSi, DALIA, OER Commons¹³⁰ and others come into play, as shown in the use case in the next Chapter 6 below. Teachers should keep in mind that tracking user progress, e.g., if students conducted a certain training module in a course, is not implemented in this open scenario. The required skills and trainings – for creators to set up a GitLab repository as well as to provide content, for readers how to use GitLab features and to contribute to trainings – is addressed here very brief only and will be subject to future research.

3.6.3 Concluding thoughts

Overall, it has to be kept in mind that GitLab is initially designed as software repository and not as OER platform. The contribution above shows how existing features are beneficial to be leveraged for OER/OEP. However, the benefits of using an open, established and running infrastructure comes along with the potential disadvantage that customisation for individual requirements might be not possible as it would be for dedicated OER software. Moreover, the contribution above shows that certain aspects are implemented by GitLab features (e.g., transparency of discussions, previous versions), others are only supported or enabled by it (e.g., a license can be displayed but the license form (type and if open/closed) has still to be chosen by the user). Table 1 summarises the main results. To our best knowledge, merge request approvals and feedback via issues have not been mentioned in the scientific literature on GitLab for OERs/OEPs yet.

4 Use Case: OERs and OEPs in NFDI4ING

The described approach with GitLab is implemented within NFDI4ING¹³¹. NFDI4ING research on concepts and services for RDM in the engineering sciences.¹³² The task area on training and education created basic RDM trainings. These trainings are publicly available at <https://education.nfdi4ing.de> (rf. Figure 1), as well as the respective underlying files in the GitLab repository at <https://git.rwth-aachen.de/nfdi4ing/education/trainingplatform> (rf. Figure 2). The trainings are designed as self-paced materials for individual

¹²³ GitLab Accessibility Conformance Report WCAG Edition: <https://design.gitlab.com/accessibility/wcag>.

¹²⁴ GitLab Accessibility Statement: <https://design.gitlab.com/accessibility/a11y/>.

¹²⁵ Saripudin et al. (2019).

¹²⁶ Da Rosa and Motz (2016).

¹²⁷ Hilton III et al. (2010).

¹²⁸ Adil et al. (2024) 14.

¹²⁹ Al Abri and Dabbagh (2018) 90, Adil et al. (2024) 14.

¹³⁰ <https://oercommons.org/>.

¹³¹ <https://nfdi4ing.de>.

¹³² Schmitt et al. (2020).

Table 1: OER and OEP with GitLab features

OER/OEP aspect	GitLab feature
Infrastructure for provisioning and management	File storage User management (permission, external users) Versioning, commit history
Accessibility	GUI, API
Provisioning	File storage with source files GitLab pages
Collaboration	Merge requests Branches
Quality	Issues Discussion in merge requests Merge request approvals
“R” criteria	Fork Built-in editors
Instructions	Wiki
Organisational	Existing infrastructure at various institutions Therefore, no additional costs and no additional legal assessment

and flexible learning. Materials are provided under a CC BY license (unless stated otherwise and except for logos), and reused materials are indicated as such.

Main goal is the open provisioning of the training materials, and the development and enhancement together with the community. Within GitLab, the team collected experiences with different formats: First, the trainings were created as PowerPoint presentation slides and converted into PDF. The provisioning of files worked but was less elegant, and the proprietary and binary file format was neither open nor could leverage incremental versioning. Second, the trainings were recreated as text-based Markdown files, enriched with images, videos, and H5P contents, and provided as GitLab Pages. Technically this way the files are open, and versioning can be done row-based, nevertheless the maintenance of this approach turned out to be too complex, and the formatting options of pure Markdown were too limited for visually appealing training materials. Remarkably, this journey through different file formats was similar to the one Atkins et al.¹³³ describe. In the current implementation, text files with the Markdown dialect LiaScript¹³⁴ are offered, with LiaScript providing more format-

ting options than pure Markdown while being quite established within OERs. We decided to have one repository per training module so that issues are clearly mapped to one training.

The team involved the community actively in the development and enhancement of the training materials. In so-called Special Interest Group (SIG) meetings, on a monthly basis each training module was presented and discussed with the community to collect feedback. In addition, the option for asynchronous contribution is provided via GitLab. Users can request access to the repository and provide changes via merge request and give feedback via issues. Although the (read) access to the training content itself and the repository (including issues) is free, the team decided to make registration mandatory for providing merge requests and issues. During the years, it happened once that spam was posted in the issues, which had to be reviewed and removed manually. The overall interaction in issues and merge requests remained so far quite low; so far, the team can only suppose if that is due to missing need or technical/organisational hurdles.

Moreover, NFDI4ING is an example of how IT centres, libraries, and domain-specific experts (here from engineering sciences) collaborate together to create and provide OERs. RWTH Aachen University's IT Centre is provisioning and operating the GitLab instance¹³⁵ as part of their institutional mission. Via DFN-AAI¹³⁶ currently 24 institutions from Germany (universities, universities of applied sciences, Fraunhofer, DLR, etc.) can access it.

Outside of the GitLab repository, the website alias¹³⁷ is used to redirect to respective trainings. Although this provides the option to have one stable and unique link to point to trainings, even if the training files might change (as in our example from PowerPoint slides to GitLab pages to LiaScript), a DOI would have been a more professional choice, but is not feasible for the website structure (as discussed before). For findability (FAIR principle “F”), trainings are separately indexed in Twillo¹³⁸, OERsi¹³⁹, and DALIA¹⁴⁰.

Organisationally, the trainings emerge from a project context, making it organisationally stable for the duration of the project. Beyond the project runtime, the GitLab in-

¹³³ Atkins et al. (2007).

¹³⁴ <https://liascript.github.io/>.

¹³⁵ <https://git.rwth-aachen.de/>.

¹³⁶ Single Sign On system within German research institutions, <https://www.aai.dfn.de/>.

¹³⁷ <https://education.nfdi4ing.de>.

¹³⁸ <https://www.twillo.de/edu-sharing/components/render/5d00f29e-85d5-4023-be2b-8f5dbcd32e66>.

¹³⁹ <https://oersi.org/resources?search=%22NFDI4ING+Basis+FDM+Trainings+f%C3%BCr+die+Ingenieurwissenschaften%22>.

¹⁴⁰ <https://search.dalia.education/>.



Fig. 1: Screenshot of NFDI4ING Basic RDM Training Platform

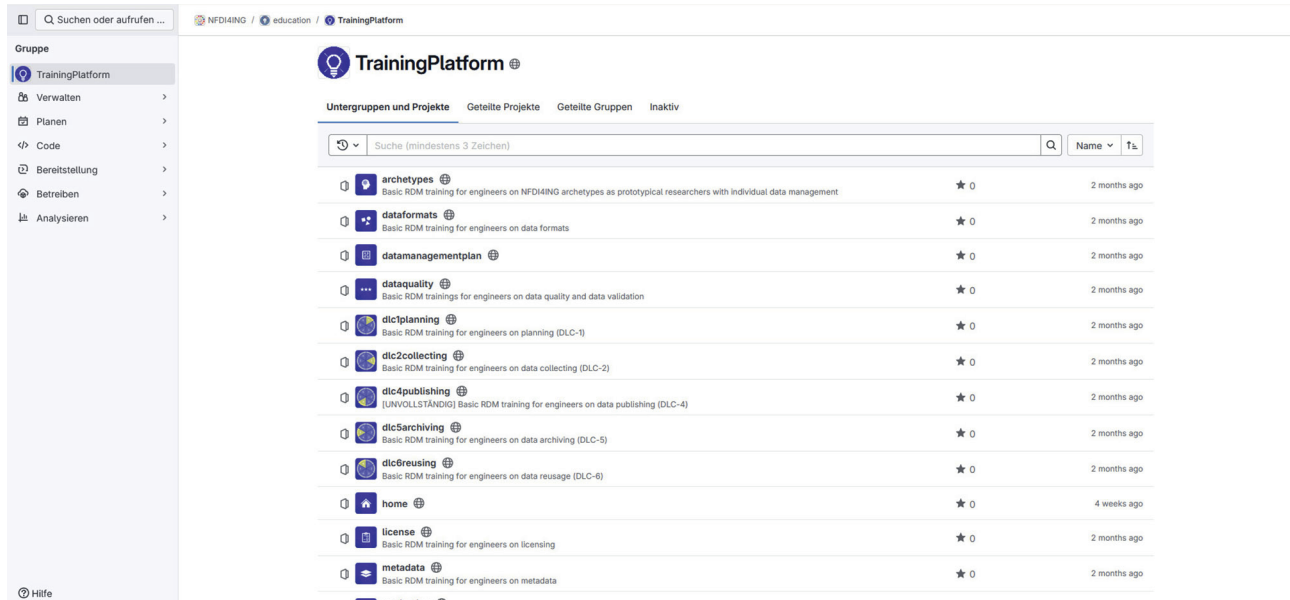


Fig. 2: Screenshot of the underlying GitLab repository

frastructure will remain, and future collaborators can be invited, in order to operate the trainings in long-term. Stakeholders are the NFDI4ING training and education team for creating and maintaining the trainings as well as community-involvement; the engineering community (researchers as well as students etc.) to consume the trainings and optionally contribute to it; and the IT Centre to host the GitLab. In a small pilot (not published), the training files have

been used in a Large Language Model to train a prototype chatbot which is answer user questions about the training content.

5 Conclusion

In this paper we presented how GitLab, initially a software management repository, can be leveraged for the management and provisioning of OERs as well. GitLab's functionalities contribute to several challenges in OERs and OEPs – namely having an established collaboration and provisioning platform, the provisioning without separated costs once the university is providing an instance, the user management, and dealing with quality of OERs. The approach is demonstrated in a use case at NFDI4ING, showing the related OEPs on the trainings. The usage of *issue* as low-barrier way to provide and display feedback, as well as the option to implement four-eye principle in *merge request approvals* have not been discussed yet in the literature. However, the experiences from the use case show that the interaction on the trainings is quite low when considering the number of issues opened or merge requests created. Whether GitLab is considered as technical hurdle for users when contributing to trainings is not investigated here.

Considering limitations of the approach, the proposed GitLab is a technical dimension of OEPs, although covering processual and social aspects as well. Pedagogy and content-wise aspects are not covered here but have to be implemented within the trainings itself; GitLab is just the platform as enabler. More experience needs to be gained in ways to encourage the community in the manner of OEPs to contribute to the trainings in form of feedbacks (issues) and content provisioning (merge requests).

The results are overall expected to be applicable for the GitHub as well. This paper only considers GitLab's core functionalities, while due to its de-facto standard additional tools have emerged for combination with GitLab. E.g., matter most can be integrated for project communication in OERs and GitBook as additional representation.¹⁴¹ Future developments from software development in git might have an impact on the provisioning of OERs and on conducting OEPs as well.

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References

- Adil, Hafiz Muhammad; Ali, Shahbaz; Sultan, Mussarat et al. (2024): Open education resources' benefits and challenges in the academic world: a systematic review. In: *Global Knowledge, Memory and Communication*, 73 (3). DOI:10.1108/GKMC-02-2022-0049.
- Al Abri, Maimoona; Dabbagh, Nada (2018): Open Educational Resources: A Literature Review. In: *Journal of Mason Graduate Research*, 6 (1), 83–104. DOI:10.13021/G8jmgr.v6i1.2386.
- Andrade, Anthony; Caine, Able; Carneiro, Roberto et al. (2011): Beyond OER – Shifting Focus to Open Educational Practices: OPAL Report 2011. In: *Open Educational Quality Initiative (OPAL)*, ed. by Ulf Daniel Ehlers. Available at https://duepublico2.uni-due.de/receive/duepublico_mods_00023933.
- Atkins, Daniel E.; Brown, John Seely; Hammond, Allen L. (2007): A Review of the Open Educational Resources (OER) Movement: Achievements, Challenges, and New Opportunities. William and Flora Hewlett Foundation. Available at <https://hewlett.org/wp-content/uploads/2016/08/ReviewoftheOERMovement.pdf>.
- Bliss, T. J.; Smith, M (2017): A Brief History of Open Educational Resources. In: *Open: The Philosophy and Practices that are Revolutionizing Education and Science*, ed. R. S. Jhangiani and R. Biswas-Diener, 9–27. DOI:10.5334/bbc.b.
- Butcher, Neil (2011): ICT, Education, Development, and the Knowledge Society. GeSCI African Leadership in ICT Program. Available at https://www.gesci.org/fileadmin/user_upload/4_ICT_in_STEM_Education_Files/ICT_Education_Development_and_the_Knowledge_Society_1_1_.pdf.
- Camilleri, Anthony F.; Ehlers, Ulf Daniel; Pawlowski, Jan (2014): State of the Art Review of Quality Issues related to Open Educational Resources (OER). Luxembourg: Publications Office of the European Union. DOI:10.2791/80171.
- Cronin, Catherine; MacLaren, Iain (2018): Conceptualising OEP: A review of theoretical and empirical literature in Open Educational Practices. In: *Open Praxis*, 10 (2), 127–43. DOI:10.5944/openpraxis.10.2.825.
- D'Antoni, Susan (2009): Open Educational Resources: reviewing initiatives and issues. In: *Open Learning: The Journal of Open, Distance and e-Learning*, 24 (1), 3–10. DOI:10.1080/02680510802625443.
- Da Rosa, Silvia; Motz, Regina (2016): Do we have accessible OER repositories? In: *2016 international symposium on computers in education (SIIE)*, 1–6. DOI:10.1109/SIIE.2016.7751867.
- Dichev, Christo; Dicheva, Darina; Agre, Gennady; Angelova, Galia (2015): Trends and Opportunities in Computer Science OER Development. In: *Cybernetics and Information Technologies*, 15 (3), 114–26. DOI:10.1515/cait-2015-0045.

- Downes, Stephen (2007): Models for sustainable open educational resources. In: *Interdisciplinary Journal of Knowledge and Learning Objects*, 3 (January), 29–44. DOI:10.28945/384.
- Dürkop, Axel; Böttger, Andreas; Ladwig, Tina; Knutzen, Sönke (2018): Ein technisches System für die kollaborative OER-Entwicklung im Experimentierfeld der TUHH. Hamburg: Technischen Universität Hamburg. DOI:10.15480/882.1653.
- Ehlers, Ulf-Daniel; Conole, Grainne C. (2010): Open Educational Practices: Unleashing the power of OER. DOI:10.13140/RG.2.2.23487.30883.
- European Commission; Directorate-General for Research and Innovation; EOSC Executive Board (2020): Six Recommendations for implementation of FAIR practice by the FAIR in practice task force of the European open science cloud FAIR working group. Publications Office. DOI:10.2777/986252.
- European Telecommunications Standards Institute (ETSI); Comité Européen de Normalisation (CEN); Comité Européen de Normalisation Electrotechnique (CENELEC) (2021): EN 301 549 accessibility requirements for ICT products and services. Available at https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf.
- Federal Ministry of Education and Research (BMBF) (2022): OER-Strategie: Freie Bildungsmaterialien für die Entwicklung digitaler Bildung. BMBF Referat Infrastrukturförderung Schule. Available at https://www.bmbf.de/SharedDocs/Publikationen/DE/3/691288_OER-Strategie.pdf?__blob=publicationFile&v=6.
- Garcia, Bérénice; Burke, Leyla; Batut (2020): Ten simple rules for making training materials FAIR. In: *PLOS Computational Biology*, 16 (5), 1–9. DOI:10.1371/journal.pcbi.1007854.
- git-scm.com; Chacon, Scott (2025): Getting Started – What is Git? Available at <https://git-scm.com/book/en/v2/Getting-Started-What-is-Git%3F>.
- Hilton III, John; Wiley, David; Stein, Jared; Johnson, Aaron (2010): The four ‘R’s of openness and ALMS analysis: frameworks for open educational resources. In: *Open Learning: The Journal of Open, Distance and e-Learning*, 25 (1), 37–44. DOI:10.1080/02680510903482132.
- Hodgkinson-Williams, Cheryl; Gray, Eve (2009): Degrees of Openness: The emergence of Open Educational Resources at the University of Cape Town. In: *International Journal of Education and Development using ICT*, 5 (5). Available at <http://ijedict.dec.uwi.edu/viewarticle.php?id=864>.
- Hylen, Jan (2006): Open educational resources: Opportunities and challenges. OECD’s Centre for Educational Research and Innovation. Available at https://www.researchgate.net/publication/235984502_Open_educational_resources_Opportunities_and_challenges.
- Lechtenböcker, Jens (2019): Erstellung und Weiterentwicklung von Open Educational Resources im Selbstversuch. In: *MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung*, 34 (Research and OER), 101–17. DOI:10.21240/mpaed/34/2019.03.02.X.
- Lübben, Sonja; Müskens, Wolfgang; Zawacki-Richter, Olaf (2023): Quality of OER: Test theoretical development and validation of an assessment tool. In: *Distributed learning ecosystems: Concepts, resources, and repositories*, ed. by Daniel Otto, Gianna Scharnberg, Michael Kerres and Olaf Zawacki-Richter, 139–60. Wiesbaden: Springer Fachmedien Wiesbaden. DOI:10.1007/978-3-658-38703-7_8.
- Navarrete, Rosa; Luján-Mora, Sergio (2015): OER-based learning and people with disabilities. In: *2015 International Conference on Interactive Collaborative and Blended Learning (ICBL)*, 25–34. DOI:10.1109/ICBL.2015.7387646.
- Saripudin, S.; Djohar, A.; Rohendi, D.; Abdullah, A. G. (2019): Comparison of accessibility of OER repositories of developed countries and developing countries based on WCAG 2.0 guidelines. In: *Journal of Physics: Conference Series*, 1402 (7), 077042. DOI:10.1088/1742-6596/1402/7/077042.
- Schmitt, Robert H.; Anthofer, Verena; Auer, Sören et al. (2020): NFDI4Ing – the National Research Data Infrastructure for Engineering Sciences. Zenodo. DOI:10.5281/zenodo.4015201.
- Schröder, Nadine (2023): Version Management in a Distributed Infrastructure for Open Educational Resources. In: *Distributed Learning Ecosystems: Concepts, Resources, and Repositories*, ed. by Daniel Otto, Gianna Scharnberg, Michael Kerres and Olaf Zawacki-Richter, 241–61. Wiesbaden: Springer Fachmedien Wiesbaden. DOI:10.1007/978-3-658-38703-7_13.
- Schröder, Nadine; Pfänder, Peter (2020): Nutzung von GitHub für Open Educational Resources. In: *DELFI 2020 – Die 18. Fachtagung Bildungstechnologien der Gesellschaft für Informatik e.V.*, 337–42. Bonn: Gesellschaft für Informatik e.V. Available at <https://dl.gi.de/items/9c3c37cb-a6c3-4aeb-92d1-8248f15adfc8>.
- Sijbrandij, Sid (2016): GitLab is open core, GitHub is closed source. Available at <https://about.gitlab.com/blog/gitlab-is-open-core-github-is-closed-source/>.
- Tuomi, Ilkka (2013): Open Educational Resources and the Transformation of Education. In: *European Journal of Education*, 48 (1), 58–78. DOI:10.1111/ejed.12019.
- UNESCO (2002): Forum on the Impact of Open Courseware for Higher Education in Developing Countries. UNESCO. Available at <https://unesdoc.unesco.org/ark:/48223/pf0000128515>.
- UNESCO (2012): 2012 PARIS OER DECLARATION. World Open Educational Resources (OER) Congress. Available at <https://unesdoc.unesco.org/ark:/48223/pf0000246687>.
- UNESCO (2017): Ljubljana OER Action Plan. 2nd World OER Congress. Available at <https://unesdoc.unesco.org/ark:/48223/pf0000260762>.
- UNESCO; Commonwealth of Learning; Butcher, Neil (2015): A Basic guide to open educational resources (OER). Edited by Asha Kanwar and Stamenka Uvalic-Trumbic. UNESCO, Commonwealth of Learning. Available at <https://unesdoc.unesco.org/ark:/48223/pf0000215804>.
- Wiley, David (2009): Response to George on “Openness”. Available at <https://opencontent.org/blog/archives/1196>.
- Wiley, David (2014): The Access Compromise and the 5th R. Available at <https://opencontent.org/blog/archives/3221>.
- Wilkinson, Mark D.; Dumontier, Michel; Aalbersberg, IJsbrand Jan et al. (2016): The FAIR Guiding Principles for scientific data management and stewardship. In: *Scientific Data*, 3 (1), 160018. DOI:10.1038/sdata.2016.18.
- World Wide Web Consortiums (W3C) (2024): Web Content Accessibility Guidelines (WCAG) 2.2. Available at <https://www.w3.org/TR/WCAG22/>.
- Zagalsky, Alexey; Feliciano, Joseph; Storey, Margaret-Anne et al. (2015): The Emergence of GitHub as a Collaborative Platform for Education. In: *Proceedings of the 18th ACM conference on computer supported cooperative work & social computing*, 1906–17. New York, NY, USA: Association for Computing Machinery. DOI:10.1145/2675133.2675284.



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