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A Federated Reference Structure for Open Informational Ecosystems

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The paper describes the concept of a federated ecosystem for Open Educational Resources (OER) in the German education system. Here, a variety of OER repositories (ROER) (Muuß-Merholz & Schaumburg, 2014) and reference platforms have been established in the recent past. In order to develop this ecosystem, not only are metadata standards necessary, but also open Application Programming Interfaces (APIs) are required in order to exchange information. In conclusion, it is essential that all relevant stakeholders agree on an explicit policy to be developed collaboratively. A metadata exchange service can serve to connect all partners.

Introduction

Digital learning content has become a common tool for teaching and learning in schools. Teachers search for materials they can integrate into their daily practice of teaching and t invest a lot of time in finding materials on the Internet that are suitable for defined learning activities.

The use of digital media is not the core objective of the learning processes and such media usually need to be adjusted to teaching and learning targets in general. In many cases, these targets expand to digital literacy, computer and information literacy. Moreover, subject-matter specific learning can be supported or enhanced by the use of digital media. Kirschner (2015) has recently pointed out that digital media should neither be considered as something special, nor as something to add to normal teaching and learning. Instead, they should be part of everyday teaching practice. Fullan (2012) argues that pedagogy, technology and the management of change processes in schools must be seen as a unit. Following that line, a number of conditions must be met. First and foremost, teachers need educational resources they can use effectively in class.

Digital resources can affect added value to teaching and learning. Digital media can combine text, audio, video and/or animations. They can easily be adapted to a certain learning group or classroom and it is easy to distribute these materials to many learners (Heinen and Kerres, 2015).

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Another advantage is afforded by the possibility to edit and rearrange materials, to combine them and to adapt them to different contexts. Moreover, these materials can be shared with other teachers. However, teachers are often unsure about their rights regarding the use and distribution of such materials. Teachers would like to know whether it is allowed to publish content on a Learning Management System (LMS) and whether they have the right to remix, share and republish materials. Many of these issues seem to be resolved by using open educational resources (OER). In this case, materials are published under an open licence that makes it easy to benefit from what Wiley (2014) called the 5R of OER: retain, reuse, revise, remix and redistribute learning materials.

OER Repositories (ROER)

Initiatives around the world have adapted the idea of OER and many OER repositories (ROER) are available (Atenas and Havemann, 2014). These fulfil several tasks in communicating the concept of OER to users. In many cases, users (teachers or learners) will be satisfied with the material they can find in one or several ROERs. At the same time, the question of how transparency across different ROERs can be enhanced remains unsolved and underrated (Conole and Alevizou, 2010). However, having a variety of ROERs at their disposal raises issues for many users. They might find it impracticable to search many ROERs to find appropriate material (Allen and Seaman, 2014). Furthermore, such OER repositories might not provide recommendations from other teachers or from teacher training institutions. While a repository might attract a sufficient number of users, only a few of them will actively participate by leaving comments. Therefore, the use of referatories, reference systems or special platforms that enable users to rate, tag and describe resources seems appropriate.

These types of services allow users to find references to OERs in many ROERs.

Different independent actors can provide Metadata in a referatory. Editorial staff can give recommendations, they can contextualise material, e.g. by topic, age group, or curricula. The same kind of activities can be performed by the users themselves. They can rate, tag and describe materials and they can add their views on a resource; teachers can report how the materials have been used in teaching and learning settings. Lastly, internet crawlers or robots can automatically aggregate metadata. Automated software can serve an important purpose by adding machine-readable licences to user-generated metadata. A user might not be aware of the fact that she or he is using OER and therefore they would not add a suitable tag. A robot, on the other hand, can find a machine-readable licence and add an appropriate tag to the user's description. Moreover, robots can use vocabularies or concordances to match different sets of metadata, and metadata can be extracted from a resource itself by means of text mining procedures (Heinen et al., 2014).

Referatories are beneficial in another way: they can include references that were not explicitly published as learning materials but can be used as such. This requires recommendation by editors or users. A recommendation by teachers or learners is of high value in this regard, while the publication or description submitted by editorial staff does not necessarily establish the material as learning content. In this case, it is the use in a learning process itself that makes the material an educational resource, not the original intention (Kerres, 2013).

In a best-case scenario, three elements are combined to establish an efficient platform:

· Web mining, which is an encompassing and cost-effective means of finding materials from a range of content providers.
· User generated content and metadata from teachers, which provide a valuable source, especially for enhancing references with educational metadata.
· A team of editors, which can be important for the initial entry of content and enrichment of contributions.

Finally, in an open informational ecosystem (see below), the reference platform must contain a mechanism to allow for the exchange of its metadata with other reference platforms.

Open Informational Ecosystems

So far, we have described a system of OER repositories and referatories that can be called an "open informational ecosystem". Such an ecosystem allows content providers to "plug into" the ecosystem by providing content and metadata and by retrieving them from a referatory. Metadata for a given content can be created by different actors, in different locations and on different platforms. Such metadata can then be merged and combined in an open ecosystem, thereby enriching the description of a resource.

While open systems allow for arranging the flow of content, resources and metadata, users can benefit from closed systems too. Finding everything in one place might be part of a uniform user experience and it is convenient, but users might experience the boundaries of such a closed system as a constraint. From an educational point of view, there are reasons to arrange teaching and learning materials in an open ecosystem (Kerres and Heinen, 2015). However, it is important to highlight that this does not imply that all aspects of a system should be open. For various reasons, it might be reasonable to impose restrictions to the right to change, remix, share and republish some resources, as for example statistical data from an official source. Depending on the setting, access to collections of resources might only be granted to a specific target group, and a closed learning management system might be most appropriate for the use of open resources. In one possible scenario, "open educational processes" are entirely built on closed resources. **Figure 1** illustrates the complexity of different arrangements.

To implement the idea of an open informational ecosystem, a decentralized and federated system of interconnected services needs to be designed. A central metadata exchange service is proposed to reduce the complexity of an ecosystem and to facilitate different players' contributions to, and their benefit from, the system. This service can manage the exchange of metadata and can map different metadata standards to each other. The service needs to offer a variety of application programming interfaces (APIs). In such a case, different providers would only need to rely on this service to be connected with all other services within the ecosystem.

A crucial point concerns the independency of the central service as it has to guarantee free and open access for all participants, that is providers and users. It is problematic to build a federated system of interconnected services as it is not only necessary to address questions of exchange formats and APIs. Moreover, complex practices – often invisible to users and / or authors – need to be aligned to attract participation from different players. Although the intermediation of reference infrastructures is challenging, it offers a good opportunity for all stakeholders since players benefit from each other by enriching the choices of users and the diversity of OERs (**Figure 2**).

The example of the German education system

The German education system largely relies on the idea of a decentralized structure where the 16 states ("Länder") all follow their own, and to a large degree independent, educational policy. Each federal state has developed a school system with its own curriculum and different quality assurance processes for the authorization of textbooks. A national infrastructure for providing learning materials and open educational resources has to take into account this complex situation.

In Germany, the federal states established educational servers ("Landesbildungsserver") in the 1990s to provide information about the structure and contents of the educational system. Most of the educational servers also
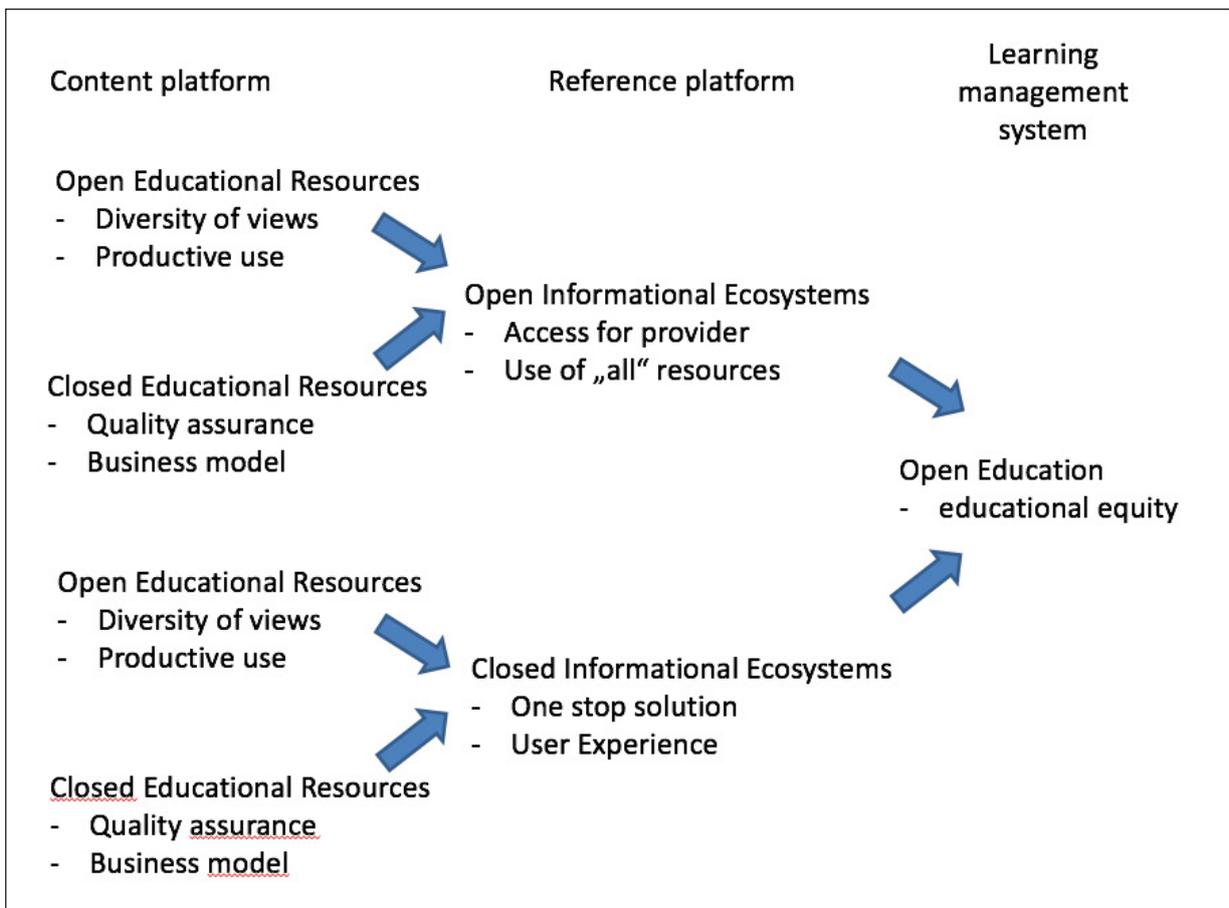
Figure 1: Aspects of openness and closeness in informational ecosystems.
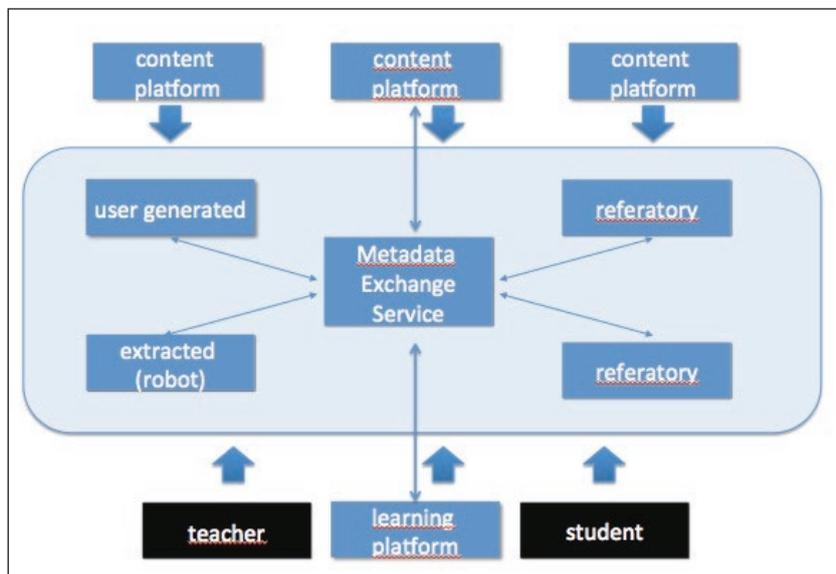

Figure 2: Federated reference infrastructure as open informational ecosystem.

provide references to educational resources on the web. References are aggregated in a database, linked to local curricula. At the national level, the German Education Server ("Deutsche Bildungsserver" www.eduserver.de) represents a network of expertise and infrastructural development that is linked to the federal state servers. Against this background, ELIXIER (Elaborated Lists in XML for Internet Educational Resources) was jointly developed in 2007, consisting of a metadata standard to exchange references and offering a common search interface for a shared pool of resources. In order to help teachers decide which resource matches their instructional situation, open and non-open educational resources (O/ER) are indexed. Additionally, ELIXIER offers an interface for a federated infrastructure, where providers of educational resources would be able to contribute to a networked reference

pool of O/ER instead of competing against each other and building closed ecosystems.

ELIXIER, the network of education servers in Germany, can be regarded as a prototype for an open ecosystem. Such an ecosystem that focuses on integrating diverse repositories has to cope with at least two challenging dimensions. On the one hand, we are confronted with a multitude of controlled vocabularies for repositories. Subject classifications differ across the federal states as do curricula, and a plurality of metadata frameworks and editorial processes can be identified accordingly. The heterogeneity of 16 state-specific standards has to be integrated into the ELIXIER framework. There are bidirectional mappings: for the export of proprietary metadata into the joint target format and vice versa for the import into the state specific classifications and further regional characteristic educational entities.

A workaround was established for ELIXIER to integrate more content from providers that also have their own taxonomies. In Germany, there exist some widely used repositories like Lehrer-Online (Lehrer-online.de), the community driven Zentrale für Unterrichtsmedien (Zum.de), or Serlo (serlo.de). A harvesting procedure was developed to integrate resources from these service providers into edutags.de – a platform based on a project that runs in parallel to ELIXIER, focusing on metadata. By means of this harvesting procedure edutags.de already contains links to several thousands of OERs. These are edited and enriched by editorial staff, subject to a pilot project, according to the ELIXIER standard. Given this process, semantic mappings are generated for the collections. Further subsets of these repositories can thus be integrated into ELIXIER and the repositories are enabled to import suitable resources from the entire ELIXIER collection and integrate them systematically into their taxonomies. The connectivity of additional repositories and their controlled vocabulary can thus be extended. Matching by human editors is ultimately supported by natural language processing mechanisms.

Different metadata schemes, on the other hand, present some challenges. Two scenarios can be envisaged to solve this problem (Ziedorn et al., 2013), the first consisting of one unified standard onto which all other metadata standards are mapped. Search options might thus be unified. By consequence, search engines like Google could better index the resources. The LRMI standard (Learning Resources Metadata Initiative) has been defined to semantically enrich search indexes with educational metadata that could facilitate finding OERs in a generic search engine without the need for a specialised portal for educational resources.

However, a dedicated platform for educational purposes is also furnished by a unified standard. Even considering the additional effort involved in building and maintaining such a platform, it would yield some substantial advantages compared to the concerns surrounding the delegation of tasks to generic search engines. One risk regarding delegation concerns the interference of search results by SEO (search engine optimization). A second risk is linked to how the richness of metadata will

be implemented for the benefit of users. For example, it is by no means clear that search engines consider domain-specific search filters. This leads to the third risk, i.e. that the discoverability of educational resources might depend on the interests of search engine providers that can hardly be predicted let alone controlled. The advantages of an independent platform that is, for example, operated by a neutral public provider, would mean that search results are ranked solely by topicality. To name some further advantages the search interface design would be customizable and it would be possible to retain control over the deployed technology.

Leaving aside the loss of domain-specific semantics by using a least common denominator, it is also very improbable that a large number of content providers would be able to agree on one standard. To some degree, coexistence of metadata schemes and interfaces can be expected. Leading to the second scenario for handling metadata: coexisting schemes are left unaltered, and none is prioritised. In the latter case, problems with federated search and interoperability will follow. A pragmatic approach would consist in a metadata exchange service that can integrate as many resources as possible by collecting a set of widely accepted schemes, translating them within that service and providing them for reuse given that diversity or, if required, making them accessible by an integrated search facility.

Current joint efforts of ELIXIER with other providers of collections may illustrate the requirements of such a metadata exchange service. The metadata specification in ELIXIER is designed according to the Learning Objects Metadata (LOM) standard; the metadata exchange is run by the import or export of XML files or by the use of a REST-API (representational state transfer - application programming interface) with the JSON (JavaSript Object Notation) data format.

To give some international examples: Open Education Europa (http://www.openeducationeuropa.eu/en) is a portal initiated by the European Commission with the aim of making OER accessible and discoverable from all over Europe. Here, exchange of metadata is based on the OAI-PMH interface (Open Archives Initiative – Protocol for Metadata Harvesting) in combination with the mandatory Dublin Core (DC) standard. Dublin Core is not likely to be suitable for educational purposes as it does not include characteristics such as learning resource type, typical age range or intended end user role (teacher, student).

Another example is I2geo (http://i2geo.net/), a European project aiming to provide interoperable and interactive teaching materials for geometry. The project received funding from the eContentPlus-program of the European Union. i2geo aggregates interactive geometry resources and is enhanced with some community and evaluation features i2geo has a LOM application profile and a Dublin Core specification as fall-back option, the interface is implemented with OAI-PMH (http://i2geo.net/files/deliverables/D2.4-Metadata-Spec.pdf).

Following the examples given above, a central instance for collecting, providing and translating is recommended as a Metadata Exchange Service. We suggest LOM as

an appropriate metadata specification, including the German application profile in ELIXIER; together with LRMI (cf. above) to yield extra connectivity for search engines. Interesting first approaches for mapping the aforementioned specifications can be found on the site of the German Initiative for Network Information (https://wiki.dnb.de/pages/viewpage.action?pageId=94678918). If necessary to account for the Dublin Core format, the required reduction of granularity is easily done. The interfaces of choice can be a lightweight REST-API with JSON (cf. above), as in ELIXIER, or alternatively the more elaborated OAI-PMH that was first designed for library applications but is also common in education. The metadata exchange service can be expanded stepwise, adding interfaces and metadata schemes depending on future acceptance and the relevance of repositories that want to join the OER network.

Conclusion

An effective provision of OERs does not only depend on a sufficient range of materials in several ROER; referatories are also necessary to collect, combine and extend metadata from different sources. The challenging task is to establish an open infrastructure together with a variety of options for interaction and the exchange of metadata.

The description of a federated structure within the distributed German education system outlines how such a structure could work. The ELIXIER network combines 8 federal educational servers as well as four additional content partners and makes a range of more than 50,000 resources available, whereby nearly 5.000 of which are described as OER. Metadata that have been created by one federal state can be used by all others. Yet, many steps still need to be taken to provide teachers and learners with all the envisaged benefits. So far, ELIXIER is restricted to the school sector and it is not yet open to all providers, authors and platforms. Another challenge is to create a concept for an infrastructure to make resources available across different education sectors (k-12, higher education, vocational training, corporate learning and life long learning). The benefit seems to be obvious but obstacles are manifold. Different sectors use different vocabularies to describe resources, thus mapping becomes more crucial. Many existing repositories and reference systems can be adapted to OER. Their integration into a federated reference structure for open informational ecosystems and OER needs further research, calling for the cooperation of many organisations.

Competing Interests

The authors declare that they have no competing interests.

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