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Metadata Standards in National Education Infrastructure: Development of Evaluation Criteria and their Exemplary Application

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Abstract: Many difficulties can arise during the implementation of a metadata standard. One reason may be the lack of prior examination of existing standards. These sometimes painful experiences led to the need for a catalogue of criteria to be used in infrastructure projects to assess suitability to the requirements. Against the National Education Infrastructure background, the paper presents an initial approach. For this purpose, criteria are developed, whose application enables a well-founded pre-selection of standards. These are discussed and tested exemplarily in three use cases - educational offerings, educational resources, and digital credentials. An overview of current developments in the area accompanies this. Overall, the paper aims to provide a basis for further discussions on the selection and handling of standards in educational infrastructures. However, so far there is little literature on this highly relevant topic. Therefore, a discussion process in the community should be stimulated as a supplement.

Keywords: metadata standards, evaluation criteria, education infrastructure, educational offers, educational resources, digital credentials

1 The Role of Standards in the National Education Infrastructure

The necessity of standards⁶ and interfaces was recognized as a crucial topic in the research and development of educational technology for decades [TK12]. However, there is little overview of the field, and many initiatives attempt to structure the field by setting their

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⁶ This paper focuses on the area of metadata standards. Even where the term "standard" is used in general, it always refers to the field of metadata standards.

own competing standards. At the same time, educational technologies are increasingly networked, data is exchanged within individual initiatives and in many educational areas. Projects such as a National Educational Infrastructure strive to map and easily connect the entire learning journey of its users. To network educational actors e.g. within a construct as the previously mentioned National Education Infrastructure (NEI) or EU-wide educational network, the use of standards and interfaces becomes a knock-out criterion for success [Kn22]. Education stakeholders face the challenge of choosing the right data exchange standard to build interoperable services.

In this field, metadata in particular has a long tradition as an important mechanism for interoperability. Starting in the library sector, metadata standards have been driven by the emergence of multimedia learning and education technologies, and not least spurred by recent OER initiatives, like WirLernenOnline⁷ or the Open Educational Resource Search Index⁸. For most types of educational content metadata standards exist. They are usually developed and disseminated by standardisation bodies with the involvement of key actors in the respective field. At the same time, stakeholders have to choose between several existing standards for one type of content. In addition, data exchange systems are implemented differently in practice; sometimes they are based on standards, and sometimes big players define proprietary formats and try to establish them as standards.

Standards describe the sequence of repetitive tasks and established processes, guidelines and definitions for handling them. The development can take place both top down and bottom up and usually involves the expertise of specialists. The form usually corresponds to a formalised document that describes the correct implementation of the respective standard as completely as possible [DI23]. There are various reasons for using standards, but most of them relate to their cooperative, relieving and sustainable effects. The need of different players to exchange objects and to define the characteristics of these objects in a general way in advance leads to the formation of standards. Standardisation itself can occur in three ways [Ge97]:

- *De-Facto standardisation* takes place through the selection or elaboration of a standard by market participants.
- In *institutional standardisation*, committees (e.g. W3C, 1EdTech, DCMI/DublinCore/asist.org, DINI-AG-KIM), standardisation organisations (CEN, ISO) or nationally recognized normalisation institutes (e.g. DIN) organise the development of standards.
- *Legislative standardisation* is achieved through the enactment of laws or regulations.

It should be noted here that the types often merge into one another. Standards are always needed when several actors cooperate and agree in advance on the shape of the objects they want to exchange. For large educational infrastructures, these objects can be any information in the form of data. If the implementation is correct, i.e. compliant with

⁷ <https://wirlernenonline.de>

⁸ <https://oersi.org>

standards, the players can interconnect and exchange their data without additional implementation effort per additional participating partner. For institutions and projects that are publicly funded, another aspect regarding the use of standards is to be respected. In order to meet the "Public Money, Public Code" requirement of the campaign of the same name, it is recommended that established and open standards be used in publicly financed projects as far as possible [Pu23]. This enables subsequent use of the data and interfaces used as well as sustainable connectivity beyond the financed project period. But how is an informed decision made to use a particular standard in the first place? There is a lack of criteria, which help actors choose the right standard from all the available options.

In this paper, we derive criteria from the evaluation of Open Source Software to the evaluation of metadata standards. These criteria are then used to evaluate standards for three exemplary content types: Educational Offers, Educational Resources, and Digital Credentials. We hope to initiate a discussion on the evaluation criteria to establish this relevant topic in research and practice, and to make it easier for future stakeholders to make informed decisions on the selection of metadata standards.

2 Criteria and Evaluation Process of Metadata Standards

Before presenting and discussing exemplary use cases of metadata standards in a NEI [Kn22], it should be clarified which criteria can be used to verify whether a standard covers the use case. As [RHG21] note, there is little prior work in the literature on the topic. In order to be able to set up founded criteria nevertheless, the criteria from the evaluation of open source software (OSS) [Wi06, Ga10] as well as generally formulated principles to the topic metadata standards [Du02] are to be combined with the criteria outlined by [RHG21] for the selection of educational standards. This results in a criteria catalogue that is generally applicable to standards in the educational environment.

[Ga10] recommends that a distinction be made between informal and formal techniques in the evaluation of software, each of which brings with it its own criteria. With the informal criteria [Me04] is referred to, whose criteria overlap partly with [Wi06]. [Ga10] recommends the use of informal criteria to pre-select options that can then be formally reviewed. Informal criteria have the property that they are difficult to measure independently, whereas formal criteria can be verified in a clearly reproducible way. This basic distinction is to be related to the criteria presented in [RHG21] for the education area, in order to verify their applicability to educational infrastructures in general.

The use and implementation of a metadata standard entails additional effort. If an exchange of data with external partners is not necessary and planned, it may be that an in-house data model developed to meet individual needs can be implemented more quickly and with less effort. The first step is therefore to *clarify the objective* of the project [RHG, p. 66]. Only with the goal of exchanging data *sustainably* beyond one's own system or the duration of one's own project does the evaluation and finally the use of an appropriate

standard become necessary. In the following two sections, the criteria proposed by [RHG21] are divided into informal and formal criteria. Where possible, it is referenced if a criterion is also found in the evaluation of OSS or generally formulated principles to the topic of metadata standards. Without reference, the criterion was developed by the authors.

2.1 Informal Criteria

For a standard to have a relieving effect, it requires *dissemination and acceptance* of the standard [Me04, RHG21, p. 65]. Acceptance usually correlates with *implementation effort and utility* [RHG21, p. 66]. Requirements for a standard are strongly *context-dependent*. A review of reference projects or exchange with partners who use the standard is useful to check the practical applicability.⁹ *Relevance and community* around a standard should also be considered [Me04]. Current developments in the respective standard should be taken into account. Standards may be revised and come out in new versions soon. The implementation of a standard is not trivial, therefore it is desirable if there is an active community around the respective standard. This can serve the exchange or also the further development of a standard. For the correct implementation, *documentation and support* [Me04, RHG21, p. 66, Wi06] are important. Ideally, examples and schemas are provided to validate the data and its implementation.

2.2 Formal Criteria

Meeting didactic and technical requirements in equal measure is a challenge that is taken into account when testing *practicality* [RHG21, p. 65]. It must be checked whether the standard covers the necessary attributes and can be supplemented with missing ones. The existence of legal or other requirements should also be checked at this point. If a standard is based on specific protocols or has further dependencies, the question of *technical debt* should be examined so as not to inadvertently burden oneself with dependencies. Formats and data models should be designed to be *interoperable* to ensure convertibility and sustainability [Me04]. If validation schemes are not provided, it may make sense to have one's own implementation *certified*. Certification can be seen as a sign of quality [RHG21, p. 65]. Not all standard documents are freely available. Obtaining them may involve *costs* [RHG21, p. 67]. It must be clarified whether financial resources are available for acquisition and use. In order to be allowed to adapt them, it is necessary that they have been published under a *free licence* [Du02, RHG21, p. 65].

Finally, other than stated by [RHG21, p.67] we consider the criterion of openness must also be taken into account, especially in the public sector in order to avoid lock-in effects. This criterion combines formal and informal criteria, which primarily concern the opportunities for collaboration and further development. In addition to the costs and

⁹ E.g. There are DIN-Specifications, e.g. DIN PAS 1032-2, DIN PAS 1068, which solved problems on a theoretical level, but did not grasp adoption.

licensing of the standard and access to the developing community, due process, compliance with the consensus principle, transparent development, fairness and opportunities for participation in the standardisation process must also be taken into account.¹⁰ A detailed elaboration is outside the scope of discussion, but will be similar to the structure of the Software Sustainability Maturity Model (SSMM) of [Ga10]. The Wiki of the Open Education Community¹¹ provides a first overview of use cases and standards to support the evaluation process of the mentioned criteria.

3 Application Fields of Metadata Standards in the NEI

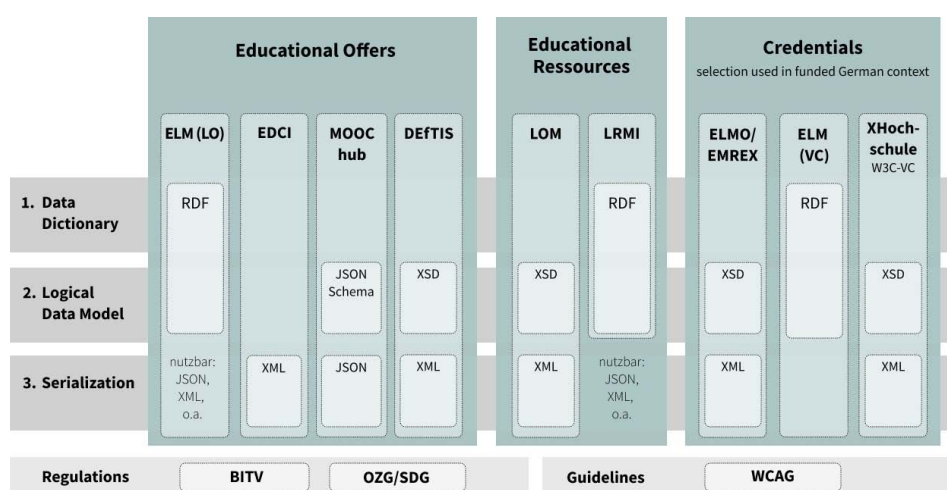


Fig. 1: Standard Overview

Metadata plays an essential role if offers, credentials, resources or contents are to be bundled or exchanged in national, European or other networks. For this purpose different data models and serialisation formats can be used. The graphic gives an impression of the variety of standards that can be used and their underlying technologies. In the following, the listed criteria will be discussed and applied to three use cases - educational offerings, educational resources, and credentials.

¹⁰ Overall, many aspects of the Software Sustainability Maturity Model [Ga10] can be transferred to the standardisation process.

¹¹ <https://confluence.edu-sharing.net/confluence/x/K4ApBg>

3.1 Educational Offers

Educational offers are time and place-bound learning opportunities. They can be found at central locations, e.g. in Germany in KURSNET of the Federal Employment Agency.¹² At a European level the Europass portal is an appropriate example.¹³ In order to present educational offers on these kinds of platforms, individual providers must make metadata of the offers available to be collected from aggregators. In addition, a platform must be able to handle this data and be able to filter and select by user specific parameters.

The use case specific *requirements* for a standard are strongly context dependent. On one hand there are “didactical” requirements for the standard to represent the contents of an educational offer. Stakeholders see the need to not falsely advertise an offer and simultaneously make an offer as appealing as possible. On the other hand, there is a need for highly structured data to optimise the discoverability of individual offers. Automated processes must be able to correctly match the offer’s data to the parameters of a given implementation. One challenge in this context will be a standardised breakdown of subjects into subject groups, which are defined differently in separate educational domains. The definition of cross-domain standards is a key to a standard's success in the context of an educational infrastructure.

EDCI¹⁴ data model, MOOChub¹⁵ Schema and ELM¹⁶ were evaluated for this use case.¹⁷ EDCI was tested as part of a prototype implementation. It is developed by the European Commission to provide a secure and sustainable infrastructure for the exchange of digital certificates. The given infrastructure also enables the representation of educational offers and was included in the prototype due to its widespread use. The MOOChub Schema is used to exchange course data (MOOCs¹⁸) in the MOOChub. A JSON schema is provided to share information about the courses, the providing organisations and other information. The amount of mandatory attributes has been kept low to easily onboard new partners. The specification only allows information in one language. ELM (also based on XML) is a further development of the EDCI standard and can be used for Educational Offers.

Two of these standards (EDCI, MOOChub Schema) have been tested in an experimental context. Both meet some of our defined informal criteria. In regards to *dissemination* the two standards differ quite a bit. EDCI being developed on the European level has a bigger reach than the MOOChub Schema which is only used in Germany and Austria. In terms

¹² <https://www.arbeitsagentur.de/kursnet>

¹³ <https://europa.eu/europass/de>

¹⁴ <https://europa.eu/europass/en/europass-digital-credentials>

¹⁵ <https://moochub.org/>

¹⁶ <https://github.com/european-commission-empl/European-Learning-Model>

¹⁷ DEfTIS (http://projekt.iwwb-files.de/PAS/DEfTIS_zu_PAS1045_Ver_5_07.pdf) is widely used within the professional education sector. It is not further examined here, because we focus here on standards applicable across all education sectors. A comparison with similar standards would nonetheless be interesting.

¹⁸ Massive Open Online Courses

of *acceptance* MOOChub is easier to implement since it is based on a simple JSON format. EDCI on the other hand is complex hence Reichow et al. [RHG21] explicitly call it not a standard but an infrastructure. Both EDCI as well as MOOChub Schema are being *developed further* as EDCI did bring forth another standard in the form of ELM. The MOOChub standard is being *further developed* and, for example, a multilingual option is currently being worked on. Both standards are *well documented and there are validation schemas* made available to support integration. Although both these standards fulfil some of the mentioned criteria both have proven to be suboptimal for this use case. The current iteration of the MOOChub Schema did not match the required attributes to communicate all data needed. Future versions can of course correct this issue. EDCI, on the other hand, is too flexible and thus difficult to evaluate. Restrictions of the EDCI template are necessary to allow a uniform presentation of the offers, which is close to an own standard. In contrast ELM has a well defined, but broader set of attributes within a class with a focus on the use case of educational offers.¹⁹ These attributes are documented in the corresponding Github repository.²⁰

3.2 Educational Resources

In this context, educational resources are physical or digital resources whose metadata can be retrieved digitally and are associated with a learning activity or experience. They differ from educational offerings in that they are not tied to place and time. In a networked infrastructure, providers of educational content want to share these resources and publish them, for example, in an overarching educational search engine.

To process that use case, the resources of the service providers must be made accessible. To keep the implementation effort of the aggregators low, it is desirable if many service providers agree on the use of a standard. When considering applicable standards, special requirements arise. Unlike library standards, such as MARC21²¹, standards for educational resources must provide a set of pedagogical attributes (e.g. audience, educational level, competency references) to provide data for faceted searching. Two standards have been established in this area, *Learning Object Metadata (LOM)*²² and *Learning Resource Metadata Innovation (LRMI)*²³. Application profiles of LOM as well as LRMI are widely used in German-speaking countries. LOM-CH²⁴ is a profile from Switzerland, HS-OER-LOM²⁵ is used by various German OER repository operators. The "Allgemeine Metadatenprofil für Bildungsressourcen (AMB)"²⁶ (General Metadata Profile for

¹⁹ In ELM educational offers are called "Learning Opportunities"

²⁰ <https://github.com/european-commission-empl/European-Learning-Model/>

²¹ <https://www.loc.gov/marc/>

²² <https://standards.ieee.org/ieee/1484.12.1/7699/>

²³ <https://www.dublincore.org/specifications/lrmi/>

²⁴ <https://www.educa.ch/de/taetigkeiten/online-dienste/lom-ch>

²⁵ <https://dini-ag-kim.github.io/hs-oer-lom-profil/latest/>

²⁶ <https://dini-ag-kim.github.io/amb/draft/>

Educational Resources) is a widely used LRMI-based profile. In addition, there are DIN and ISO standards that could potentially be used, but to the authors' knowledge have not found widespread use. Since the beginning of 2020, there is an initiative at IEEE, which deals with the further development of LOM, since the used attributes and value lists are partly outdated according to their own statement. Also other metadata concepts have been established in the meantime, which are to be incorporated into the new development "Learning Metadata (LMeta)"²⁷.

In terms of *acceptance and dissemination*, the LOM and LRMI standards are considered more closely, as they are *up-to-date and have a strong community*, which can be seen in the publication dates of the application profiles (LOM-CH 2020, HS-OER-LOM 2021, AMB 2023). For the HS-OER-LOM and AMB profiles, there is an active community within DINI-AG-KIM, which meets monthly, answers questions and takes care of further developments.²⁸ All mentioned standards and application profiles are *well documented*. *Practicality* is guaranteed, as the mentioned standards are used by many actors in the (O)ER environment. HS-OER-LOM is limited to the university sector, LOM-CH to the school sector. The application profiles can be obtained *free of charge* and are *openly licensed*, so that an adaptation to further needs is possible. According to their own statement, LOM-CH will not be further developed.²⁹ For the German-language profiles HS-OER-LOM and AMB suggestions can be submitted to the above-mentioned group. LRMI as the basis of AMB is also being developed openly. The developments of LRMI as well as AMB and HS-OER-LOM are thus very open, participation in IEEE Working Groups is also possible. The biggest difference is with regard to their *technologies used*. While LRMI does not specify anything about serialisation because it builds on RDF, AMB specifies the use of JSON-LD³⁰, SKOS³¹ as well as general web standards. LOM-CH does not specify an interchange format at all. More commonly, LOM data is serialised in XML, as is the case with HS-OER-LOM. These, in turn, are mostly exchanged via OAI-PMH interfaces in the education sector.³² Overall, the popularity of *purely* XML-based standards in the education sector tends to decline, which can also be seen in the further development of the "Europass Learning Model" (previously XML, now RDF) or the "Learning Metadata" standard (also RDF).³³ This supports the thesis set up by [Du02] already 2002 that syntax and semantics of metadata elements should be independent. LOM and LRMI *certifications* are not offered. However, schema files for both standards are available in some profiles. It can be concluded that both compared standards and their application

²⁷ <https://development.standards.ieee.org/myproject-web/public/view.html#pardetail/8290>

²⁸ <https://wiki.dnb.de/display/DINIAGKIM/OER-Metadatengruppe>

²⁹ <https://www.educa.ch/sites/default/files/2020-11/applikationsprofil-lom-ch-v2.1-de.pdf>, p. 6

³⁰ <https://www.w3.org/TR/json-ld11/>

³¹ <https://www.w3.org/TR/skos-reference/>

³² The use of OAI-PMH is much more widespread in the library sector, from where it was presumably transferred to the OER repositories.

³³ RDF can be serialised in various formats, e.g. XML, JSON, Turtle. XHochschule (see discussion below) uses XML, but also uses RDF components [X23, p. 16].

profiles are applicable for the mentioned use case. Overall, a slight trend towards RDF-based data models can be observed on a German, European and international level.

3.3 Digital Credentials

A digital credential is a digital machine-readable record that contains statements about an individual and is issued by an educational institution after a learning experience. A credential describes an activity, assessment, achievement of a learning goal, authorization, or qualification [Eu23]. In a joined educational infrastructure, service providers want to issue credentials to users and process previously acquired credentials in order to offer user-specific services. The Online Access Act at the national level and the Single Digital Gateway Regulation at the European level show that administrative services will take place digitally in the future [Di23]. Therefore, connectivity and compatibility with existing initiatives such as EMREX³⁴ or Erasmus Without Paper (EWP)³⁵ are important.

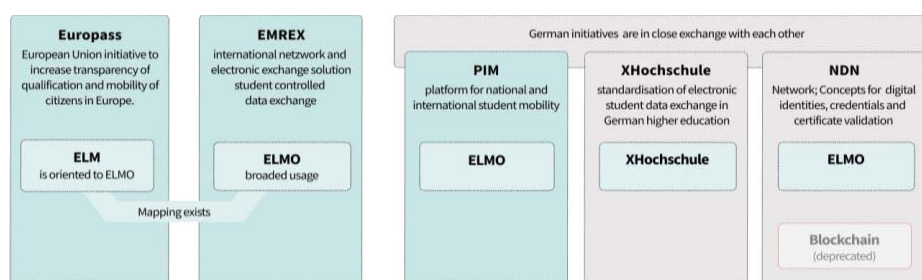


Fig. 2: Standards for Digital Credentials

Developments in this field are diverse and there are currently eleven different projects or standards in Germany [Re21]. The three largest projects are Platform for Inter*national Student Mobility (PIM)³⁶, XHochschule³⁷, and Netzwerk Digitale Nachweise (NDN)³⁸. NDN changed its original blockchain-based approach after public criticism and a hack³⁹ and now uses ELMO (also used in EMREX) as its basic exchange format. On a European level, the European Learning Model (ELM) is also addressing this issue. XHochschule is developing a national standard in close coordination with EMREX and ELM.

At this point, the three standards ELMO (EMREX), ELM and XHochschule are examined with regard to the evaluation criteria. All three standards are developed in close coordination and are suitable for *achieving the objective* of the use case. There is a close

³⁴ <https://emrex.eu/>

³⁵ <https://erasmus-plus.ec.europa.eu/european-student-card-initiative/ewp>

³⁶ <https://pim-plattform.de/>

³⁷ <https://www.xhochschule.de/>

³⁸ <http://netzwerkdigitalenachweise.de/>

³⁹ The use of blockchain technology in that field was already marked as urgently to be cleared by [Re21, S. 18]

cooperation between PIM and XHochschule [Re21, S.11]. At the same time, ELM explicitly emphasises being aligned with ELMO.⁴⁰ In terms of *acceptance and dissemination*, ELMO's use in PIM makes it the most widely used standard with, according to its own data, 1674 connected institutions and more than 68,000 data transfers between partners. ELM is used on Europass platform as part of the European Commission's Europass Digital Credentials Infrastructure and is based on W3C-VC.⁴¹ XHochschule also uses this standard, but is still in pilot operation. All three standards are characterised by a *high degree of relevance and an active community*. This is evident from the open development on GitHub. The same applies to *documentation and comprehensibility*. Documentation and validation schemes can be found for all standards. Only in the case of ELM, which can also be used for the presentation of educational offerings and is correspondingly complex, the presentation as a pure Markdown document can certainly be made clearer. ELM and ELMO have already been *tested in practice*, XHochschule is in the test phase. All three standards are openly licensed. The three projects are characterised by exemplary cooperation. This is probably since there is a strong political will in the background to make the topic successful and compatible. XHochschule as a national OZG project will certainly become authoritative in Germany; moreover, it will be compatible with ELM at the European level through the common denominator W3C-VC. The close contact with ELMO and ELM to ensure mapping and convertibility is defined as a design decision in the specification of XHochschule [XH23, p.15]. For further research and evaluation, “mapping” criteria should be added to the formal criteria list developed in section 2.2 as it ensures sustainability and future development.

4 Outlook to Further Development

The selection and application of standards is a complex task for which there is little literature to date that provides support in terms of applicable criteria. This lack sometimes even leads to the statements made by Stemmer and Goldacker that an assessment would often be made by the subjective assessment of an expert person. Just in certain cases, the decision on which the assessment is based could be traceable to objective criteria [SG14]. This will be countered at this point by the approach of this paper, which derives and develops criteria to place them on an objective basis that leads to a reasoned decision in a selection process. The criteria and their brief discussion on three use cases are intended to create a first impression with regard to their practicability and applicability and to stimulate further discussion and development. Further development would be helpful, for example offering a point system as desired by Stemmer and Goldacker. Overall, it should be noted that the topic is highly complex and initiatives such as the OEde Confluence within the NEI are welcome as they provide a common knowledge base and forum for exchange on the topic.⁴² This makes it easier for other stakeholders to get started and make

⁴⁰ <https://github.com/european-commission-empl/European-Learning-Model>

⁴¹ <https://www.w3.org/TR/vc-data-model/>

⁴² <https://confluence.edu-sharing.net/confluence/x/4wGhB>

choices. At the same time, it can also make it clear which actors are familiar with which standards, in order to be able to gather experience and take it into account in the evaluation.

5 Recommendations on Using and Developing Metadata Standards

Metadata standards are critical for organising, describing, and managing objects of all kinds in an educational infrastructure. As such, there are recommendations that can guide the use and development of metadata standards. It is essential to adopt widely recognized metadata standards that are interoperable across different systems. Especially for a national platform, European and international developments have to be considered. Furthermore it is important to involve stakeholders from different areas of education in the development and implementation of metadata standards from the beginning on. These stakeholders can include educators, librarians, technologists, developers, and instructional designers, among others. The involvement of these stakeholders help ensure that metadata standards are chosen and developed to meet the needs of the education sector and are practical to implement as well. Lastly, it is recommended to join metadata groups and communities early on, especially if one's use case seems to require modifying existing standards. A lot of expertise is present in the groups around IEEE, LRMI or DINI-AG-KIM, which might be of help regarding practical experiences and best practices. If there is no standard present meeting the requirements, exchange with other partners having the same use case might lead to a new specification, which might then be transformed to a standard. To guarantee maintenance and sustainability of the developed specification it should be early on developed in a standardisation community.

6 Conclusion and Outlook

The paper collected and listed criteria that can be used to evaluate suitable metadata standards for a use case. For this purpose, criteria from the evaluation of open source software were used and transferred to evaluation of metadata standards. The criteria were then applied to three actual use cases of a NEI as examples and briefly discussed. This discussion can only be exemplary in this brevity, but show how the criteria can help with evaluation. In the context of BIRD, the prototype of the National Education Platform, it has been shown that such catalogues of criteria are lacking. Especially in a project that is standard agnostic and that cannot and should not prescribe the use of standards in advance, an appropriate criteria catalogue is necessary in order to be able to select standards for corresponding use cases in a well-founded way, both by oneself and with the partners involved. This paper makes an initial proposal for criteria and their application and opens up a further discussion in the evaluation of metadata standards.

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