A Review of the Literature on Teaching and Learning Environments

Completed Research

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Abstract

In the fields of research and education, knowledge is being generated continuously and made available worldwide through digital transformation. Expert interviews with the employees of an education service provider have shown that lecturers in system-based education are increasingly overstrained with the amount and the diversity of teaching materials. The identified problems impair (continuing) education and thus adversely affects the teaching quality. Different approaches in the area of teaching and learning environments (TLEs) attempt to solve individual problems in isolation. However, these approaches have not yet been brought together in a structured way or integrated into a common concept. In the context of this paper, a structured literature review on TLEs is conducted. Existing concepts are presented and analyzed. LOM standards, meta-objects, hierarchization and reusability provide promising approaches to solve the identified problems. In further research works, the summarized concepts and the integration into an extensible meta-concept should be investigated.

Keywords

Teaching and Learning Environment, Curriculum Design, Literature Review, Content Analysis.

Motivation

Since the beginning of the 21st century, globalization and digital transformation influence the field of research and training (Kergel and Heidkamp 2016; Obermaier 2016). This goes along with the permanent progressing specialization in various fields of expertise. Continuously, new knowledge is generated and also published (Röder 2003). Through digital transformation, the extensive knowledge is made available globally and can be used via worldwide data networks. However, nowadays, a web-based search query provides more results than usable (Röder 2003). Another problem is the lack of qualitative evaluation of these results. As a consequence, the retrieval of relevant, high-quality content becomes more difficult (Kergel and Heidkamp 2016; Röder 2003). The plentiful knowledge is partly not prepared didactically and in addition, individual requirements or demand-oriented forms of knowledge transfer are often missing (Röder 2003).

Based on the result of semi-structured expert interviews with the employees of an education service provider, lecturers are increasingly overstrained with the amount and the diversity of learning objects. They also point out that the regular updating of documents is hampered by rapidly evolving technologies. Since the rise of modern information technology (IT) almost no domain is free of IT tools (Rautenstrauch and

Schulze 2003). Thus, IT-related knowledge transfer becomes essential during all phases of life and independent of someone's education and profession. This is particularly evident in system-based teaching, where practical knowledge is to be imparted. The circumstances described above impair, among other things, the (continuing) education and this adversely affects the teaching quality (Mishra and Koehler 2006). Summarizing all issues, this results into an increasing demand for teaching and learning environments (TLEs) that help transfer necessary knowledge in an appropriate manner (Rautenstrauch and Schulze 2003).

By developing and deploying those TLEs (compositions of teaching material, an application or information system and a model organization to make system-based teaching as realistic as possible), education service provider try to solve these problems. Developers of such TLEs, so called curriculum designer, are confronted with several challenges at the same time. The growing variety of technologies (e.g. Internet of Things, Industry 4.0 or Artificial Intelligence) and topics entails an increasing demand for new or updated teaching material. Empirically, despite many innovations and changes, parts of materials do not become obsolete (in their entirety). For that matter, reusability of a material or parts of a material is a key characteristic for solving this problem (Zhuang 2006). Additionally, as a result of the Bologna Process, a more practice-oriented way of teaching is demanded in higher education (Paetz et al. 2011). When creating a TLE with the intention of practical transfer of given learning content, designers need reusable learning elements of three different types: teaching material, IT system and model organization. Especially for the curriculum designer, this also increases the complexity of developing teaching materials: The interplay of didactic requirements, content dependencies and real-world IT systems has to be taken into consideration in order to meet the conditions for the optimal education of learner in relation to certain technologies.

In this research area, there are different approaches trying to solve the same or at least similar problems. While the Technological Pedagogical Content Knowledge (TPCK) model proposes to align technology, content and pedagogy quality (Mishra and Koehler 2006), the actual design of TLEs with respect to this remains a challenge. In order to evaluate the state of the art in this field, a structured literature review is conducted based on keyword search (Seuring and Müller 2008). Additionally, forward and backward search is conducted based on relevant publications (Webster and Watson 2002). Finally, the content analysis and its results are presented within this paper.

Since the topic 'teaching' penetrates many fields (whether higher education or knowledge transfer in organizations), a very general focus is set. This work is primarily aimed at scientists who want to gain an overview of this TLE topic. In order to demonstrate the relevance of the topic for teaching as well as for curriculum design, research gaps are identified. This also derives general needs for research and actions. The following research questions are addressed:

- Which areas deal with TLEs?
- Which approaches/concepts already exist in these different areas?
- How does the investigated approaches differ from the initially motivated case and what conclusions can be drawn as a consequence?

In order to answer the research questions, the paper is structured as follows. At first in section 2, important terms are defined and the research design is explained. Section 3 describes the search process in more detail and also contains a content analysis. In section 4, the contents of the identified publications are discussed in the context of the research questions, before the paper ends with a conclusion in section 5.

Research Design

At the beginning of the section, important terms for the literature review are defined. Based on this, the databases to be examined are presented and the search method is described.

Definitions

Both popular and scientific literature often use the terms learning system and learning environment synonymously (Röder 2003). A learning system supports "the transfer, practice, assessment and evaluation of knowledge and skills" (Engesser et al. 1993). Kerres defines learning environments by their characteristic mix of media and tools (Kerres 1998). Media means either a single media object such as an electronic document or a video, or a combination of media objects like a learning module or curriculum. Tools are, for example, PC lab arrangements including IT systems and simplified models of real-world objects. Kerres postulates further that learning environments support the lecturers by making a choice regarding essential factors of an education system (learning objectives, learning contents and teaching methods). As a consequence, the process of transfer knowledge and competence is fostered. Häusler/Bosse define learning systems and learning environments in a similar but more specific way applying Systems Theory (Häusler and Bosse 2018). They also visualize such a construction to make the topic more tangible. A deeper insight is not provided here, detailed explanations can be found in their paper instead. Considering the motivation, the following hypothesis is put forward: Expandability and reusability are essential characteristics of a learning environment and extend explicitly the previous definitions.

Source and Search

For the purpose of identifying relevant publications, a total of eight search engines are used. This increases the diversity of the result set, which contains subsets of different source catalogues or databases. In addition, the risk that search algorithms and search optimizations always lead to the same or even wrong partial results sets is reduced (Yu et al. 2017). In detail, the used search engines are: ACM Digital Library, CiteSeerX, DBLP Computer Science Bibliography, Google Scholar, IEEE Xplore, iJET, SpringerLink, and UBfind. These search engines are chosen for their extensive databases, their accessibility and their technical relevance. As suggested by Seuring/Müller (Seuring and Müller 2008), the search terms are divided into two clusters, which can be derived from the motivation section (teaching and learning environment; curriculum design). The relevant search terms are deduced from the definitions and supplemented by synonyms as well as similar technical terms. Terms are selected solely, if they occur frequently and predominantly in the appropriate context during the unstructured formal search. The following table lists all search terms.

Teaching and Learning Environment (I)	**Curriculum Design (II)**
Teaching and Learning Environment	Curriculum Design
Teaching Environment	Curriculum Development
Learning Environment	Teaching Material
Teaching and Learning Platform	
Teaching Platform	
Learning Platform	

Table 1. Search terms per cluster

As shown in the table, the terms are assigned to the two clusters (German equivalents are also used for the search). In the further process, the combinations always consist of terms from different clusters but the same language. Creating a combination, a maximum of one term per cluster is selected. This is necessary in order to limit the number of possible permutations to a manageable amount. In order to carry out a target-oriented investigation within and across clusters, the search is conducted in a three-step procedure. The first two steps represent the structured keyword search (by means of search terms and combinations). In the third step, the publications proved as relevant are used to identify further possible sources.

As pointed out by Webster/Watson, the identified journals and conference proceedings are particularly suitable for this purpose, as they are checked for further relevant contributions (Webster and Watson 2002). Moreover, they recommend forward and backward searches. This procedure evaluates all references of a relevant contribution and also all publications which reference contributions that are already classified as relevant (Niedermair 2010).

During the investigation, search strings are used. For this purpose, the phrased strings are linked by the logical operator AND. The search results obtained by one of those queries represent the result set M. In order to limit the number of publications to be analyzed fully, a filtering process depending on the query cardinality $|M|$ is applied: first, all sets with $|M|>100$ are neglected, after which title filtering is applied to all sets with $50<|M|\leq 100$. The remaining papers as well as the sets with $10<|M|\leq 50$ are subsequently filtered by abstract, before these results and the queries with $|M|\leq 10$ are finally filtered based on content.

Review and Revision

After the search method has been specified, the details of the search process are described in this section. Consequently, the obtained results are analyzed.

Search Process

In the first step of the search process, the identified terms from Table 1 are used. Therefore, 17 search strings are applied to eight search engines, leading to a total of 136 search queries. The number of results per query had differed heavily depending on language and search engine. 67 search queries (ca. 49%) led to result sets which can be further analyzed ($|M|\leq 100$).

As part of the second step of the search process, combinations of terms are constructed. Thus, the number of permutations is reduced to 36, leading to 288 possible search queries. Since some terms are completely evaluated in the first step, combinations that included these terms are not considered in this step. From the remaining 144 processed search queries, 41 returned result sets that could be further processed (ca. 28%).

In the third step of the search process, the relevant proceedings and journals that have been identified in the first two steps are analyzed completely. Additionally, forward and backward search are conducted on sources with high relevance. To the 1,831 works that have been found in the first two steps, the third step adds 331 works, leading to a total number of 2,162 publications. By applying the filtering process described above, 35 works are selected that have relevance to the formulated research questions. In the following, the papers identified as topic-relevant are categorized and analyzed.

Content Analysis

As no comprehensive theory exists for the field of TLEs, the first categories for analysis are defined based on the practical problems of designing TLEs in the field of system-based education stated in the expert interviews. Furthermore, additional categories are defined within the content analysis for papers dealing with TLE aspects that have not been identified before, leading to the following set of 15 categories:

- **(1)** Dependencies of learning objects (LOs)
- **(2)** Classification of LOs
- **(3)** Own learning object metadata (LOM)
- **(4)** Standards for LOM
- **(5)** Annotations
- **(6)** Construction of meta-objects from elements
- **(7)** Hierarchies in teaching materials
- **(8)** Hierarchies in system landscape
- **(9)** Hierarchies in model
- **(10)** Feedback to LOs
- **(11)** Multiple teaching material authors per LO
- **(12)** Differentiation between author and lecturer
- **(13)** IT as simulation environment
- **(14)** E-Learning
- **(15)** Central online repository for LOs

By assigning categories to all relevant publications an overview about the state of the art can be given. In the following, the topics and the respective works are analyzed briefly and evaluated in terms of the research objective of this paper.

Dependencies of LOs stands for the hypothesis that learning objects cannot be combined arbitrarily. In some cases, a certain LO is required to be processed by a student in order to understand another one. Already 1968, the Joint Task Force on Computing Curricula (CC) and the ACM acknowledged these dependencies between learning contents in the IT and, since then, recommends to consider these (Atchison et al. 1968; CC et al. 2013). More recent approaches such as the one of Chan/Kwok aim at grouping and relating the different topics (Chan and Kwok 2014) which should support to process all topics in a suitable sequence. On the other hand, Maurer as well as McPherson/Baptista-Nunes state that the scope of these activities should go beyond individual subject areas to create an interdisciplinary cooperation across an entire university (Maurer 1999; McPherson and Baptista-Nunes 2007). Anyway, all authors agree on the fact that dependencies between LO exist and should be analyzed. However, the continuous increase in relevant topics in context of IT leads to problems as Lämmel points out (Lämmel 2010). In the context of a constant number of lectures, it becomes more complicated to teach required knowledge completely.

Works that do not assess and utilize detailed metadata for LOs but group them by assigning object types are sorted into the category **classification of LOs**. For instance, Auinger/Stary distinguish 15 types of content such as motivation, case study, test, and summary (Auinger and Stary 2005). Additionally, these types are mapped to classical learning paradigm such as cognitivism or constructivism.

In contrast to the simple classification by a single attribute, sources in the category **own LOM** define more or less complex meta-models and apply them to learning contents. Brito et al., for example, defined own metadata to allow lecturers to select appropriate contents and leave ratings (Brito et al. 2006). Other authors, such as Höhn as well as Lemnitzer et al., build upon standards such as IEEE LOM and extend these according to their requirements (Höhn 2002; Lemnitzer et al. 2007).

In the category **standards for LOM**, works are collected that focus on the utilization of metadata. The standard IEEE LOM is included here as well as works such as by Pawlowski who analyzed LOM standards and gives an overview about potential application areas (LTSC 2002; LTSC 2011, Pawlowski 2004). Other authors use LOM standards to identify and combine LOs. A comparison of sources from the categories 'classification of LOs', 'own LOM' and 'standards for LOM' reveals that the majority of works conclude to use well-defined meta-models and, thus, LOM standards (Flohr 2004; Höhn 2002; Klerkx et al. 2010; Lemnitzer et al. 2007; Maycock and Keating 2014; Mazloumi 2010; McPherson and Baptista-Nunes 2007; Pahl and Melia 2006; Röder 2003). Although, as Pawlowski points out, not all standards are compatible, at least the LOs within a standard are.

Work that uses additional elements to assign unstructured information to any object (such as LOs) is allocated to the **annotations** category. The information is unstructured because it cannot be stored as standardized metadata. Zhuang explains that annotations are necessary to transport feedback regarding any LO without leaving the appropriate system directly to the curriculum designer, and on the other hand to note thoughts, information and comments immediately in the system (Zhuang 2006). This is especially important if several curriculum designers are working on the same object at different times or locations. Besides metadata, Lemnitzer et al. use annotations to introduce automatically generated keywords of a LO as an additional search criteria (Lemnitzer et al. 2007). As shown by the two publications, annotations have the potential to support the work of curriculum designers.

Sources that combine LOs to create new meta-objects are assigned to the category **construction of meta-objects from elements**. For example, Auinger/Stary use the same LOs to generate either full-text objects for lectures or additional information for self-study as needed (Auinger and Stary 2005). Thereby, combinations of meta-objects can also create new meta-objects (Meier and Holl 2000; Pouyioutas 2010). Some publications consider in detail how it is technically feasible to share LOs with other services or how LOs can be combined automatically (Klerkx et al. 2010; Lobin and Stührenberg 2003). Most scientists agree that the creation of meta-objects from several LOs works best if LOM standards such as those of the IEEE are taken into account (Maycock and Keating 2014; Mazloumi 2010; Pahl and Barrett 2004; Röder 2003). However, if hierarchies can arise from meta-objects and if their lowest level consists of LOs or BLOBs (according to Röder, the smallest elements whose combination results in meaningful LOs (Röder 2003)), then hierarchies must also exist within the teaching materials (Meier and Holl 2000).

Each of the TLE components (here: material, system and model) has its own hierarchies, but these are interdependent. Therefore, the categories **hierarchies in teaching materials**, **hierarchies in system landscape** and **hierarchies in model** are used to check whether this has already been investigated by other scientists. In summary, about one third of the publications agree that the teaching materials are structured by hierarchies (Britell et al. 2013; Busetti et al. 2006; Franze et al. 1999; Meier and Holl 2000; Pouyioutas 2010; Wang et al. 2007). In particular, the combinations of documents (such as exercises and case studies) to lectures, from lectures to courses, from courses to modules and from modules to whole degree programs are typical examples of those hierarchies. However, no publications could be found that have already investigated hierarchies in systems or models of a TLE. Accordingly, no sources were found that dealt with the dependencies of hierarchies on each other.

Moreover, the topic of **feedback on LOs** is dealt with in some publications. The main aim is to transmit losslessly constructive criticism from the user to the curriculum designer via suitable feedback channels. Both Britell et al. and Zhuang see a connection of the object with a freely assignable comment as a solution

(Britell et al. 2013; Zhuang 2006). On the other hand, Brito et al. see the extension of the metadata model as the means of choice (Brito et al. 2006). Both methods serve this purpose. However, comments or annotations that are not part of the metadata require additional mechanisms for the design of the TLE. For the categories **multiple teaching material authors per LO** and **differentiation between author and lecturer**, the publications are examined to see whether they describe how multiple teaching material authors can participate in LOs and also whether teaching material authors are explicitly separated from roles like users and lecturers. In fact, Brennecke/Selke, Britell et al., Brito et al., Busetti et al. and Gonzalez-Barahona et al. demand that users form digital communities to share teaching materials and work together on new materials (Brennecke and Selke 2000; Britell et al. 2013; Brito et al. 2006; Busetti et al. 2006; Gonzalez-Barahona et al. 2006). Zhuang supports the concept thatseveral teaching material authors exchange their ideas and create content together, but also makes a clear distinction between the roles of curriculum designer and actual user (Zhuang 2006). Already in 2002, Feuerhelm et al. explicitly separated the two roles (Feuerhelm et al. 2002). With the publication of the IEEE standard for Learning Technology Systems Architecture (LTSA), this was defined officially as standard (LTSC 2003).

Many sources see IT more as a support for creating and providing learning objects (Auinger and Stary 2005). In the field of education, IT is also used in addition to classical forms of teaching. However, as Douglas has already postulated, IT should be used to improve the nature of teaching in general (Douglas 2012). Publications which pursue the target of making education more modern and more tangible based on simulated environments are assigned to the topic of **IT as a simulation environment**. Already in the mid 90s, Balkovich et al. summarized the possibilities of simulation at MIT (Balkovich et al. 1985). Despite lower IT performance, they presented simulations of complex systems, laboratories or other special learning environments. Furthermore, standards such as the IEEE LTSA already include environments that simulate complex processes and bindings (LTSC 2003).

Around 57% of the sources classified as relevant for the research questions have dealt with the topic of **e-learning**. In most cases, the concepts were explicitly developed for the use in distance learning (such as Röder (Röder 2003)) or hybrid learning (such as Henrich/Sieber (Henrich and Sieber 2010)). They carried out Investigations only in this specific context. Although this work does not refer to e-learning, some concepts and ideas from the publications could be adopted.

Klerkx et al. as well as Pahl/Barret initiate the topic **central online repository for LOs** (Klerkx et al. 2010; Pahl and Barrett 2004). They describe technical implementations for the provision of LOs via web service. However, the availability of LOs via internet (through a kind of 'Learning Object as a Service') is not the subject of this work.

Figure 1 shows the distribution of all publications identified as relevant across the defined categories. The flags ('O') indicate that a work is assigned to the respective category. As can be seen, most publications dealt with the following topics: Standardization for LOM, construction of meta-objects from LOs, hierarchies of teaching materials in its entirety and e-learning. The evaluation of the identified publications as well as the literature review process itself confirm the impressions of the informal search. It is necessary to investigate how a TLE consisting of teaching materials, IT system (landscape) and model (organization) has to be constructed. In addition, it has not been cleared yet in the literature how the individual elements of such a TLE relate to each other. Afterwards, for the curriculum designer, it can be clarified how a TLE can be derived from the requirements according to the set of all elements.

Discussion

The first publication identified by means of the literature review appeared in 1968 and deals with dependencies of LO. Other scientific works extended the general approach independently to cover the aspects of interdisciplinary cooperation (to impart cross-topic learning contents) and thematic groupings (to create didactically meaningful sequences of teaching materials). Lämmel addresses an additional, specific problem. He warns of the knowledge growth and thus, the accompanying consequences for the education.

In order to be able to structure a large number of LOs and place them in a higher context as well as to make the complexity of the 'overall construction' manageable, the design of well-defined, extensible metadata models is all the more important. The use of such standards is the subject of 14 publications. Just few authors define individual metadata for their purposes. A possible follow-up questions is whether extendable standards can integrate such special cases, because the typing of LOs and their assignment to learning paradigms or other didactic basic concepts driven forward by Auinger/Stary are desirable. Such an extension could counteract the initially described deficit of the often missing didactic preparation.

	Categories														
Identified Publications*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Atchison et al. 1968	O														
Blakovich et al. 1985			O							O	O				
Franze et al. 1999							O							O	
Maurer 1999	O													O	
Brennecke and Selke 2000											O			O	
Meier and Holl 2000						O	O				O			O	
Feuerhelm et al. 2002												O		O	
Höhn 2002			O	O		O								O	
LTSC 2002				O		O	O								
LTSC 2003												O	O		
Lobin and Stührenberg 2003						O								O	
Röder 2003				O		O	O							O	
Flohr 2004				O										O	
Pawlowski 2004				O										O	
Pahl and Barrett 2004				O											O
Auinger and Stary 2005		O				O	O							O	
Busetti et al. 2006							O			O	O				
Brito et al. 2006													O		
Gonzales-Barahona et al. 2006											O				
Pahl and Melia 2006				O		O								O	
Zhuang 2006				O	O	O				O	O	O		O	
Lemnitzer et al. 2007			O	O	O	O								O	
McPherson and Baptista-Nunes 2007	O			O			O							O	
Wang et al. 2007						O	O							O	
Henrich and Sieber 2010														O	
Klerkx et al. 2010				O		O	O								O
Lämmel 2010	O														
Mazloumi 2010				O		O	O							O	
Pouyioutas 2010						O	O							O	
LTSC 2011				O		O									
Douglas 2012													O		
Britell et al. 2013							O				O				
CC et al. 2013	O														
Chan and Kwok 2014	O														
Maycock and Keating 2014				O		O								O	
	6	**1**	**3**	**14**	**2**	**15**	**12**	**0**	**0**	**3**	**7**	**3**	**3**	**20**	**2**
* sorted by year of publication	(17%)	(3%)	(9%)	(40%)	(6%)	(43%)	(34%)	(0%)	(0%)	(9%)	(20%)	(9%)	(9%)	(57%)	(6%)

(1) Dependencies of LOs
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(8) Hierarchies in system landscape
(9) Hierarchies in model
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(11) Multiple teaching material authors per LO
(12) Differentiation between author and lecturer
(13) IT as simulation environment
(14) E-Learning
(15) Central online repository for LOs

Figure 1. Distribution of identified publications across all categories

Furthermore, the publications in the topics meta-object formation and hierarchies in teaching materials have proven to be very relevant for this paper. By using both concepts, the multiple use of a LO is brought to the fore. In addition to the structure of a single LO, the structure of several LOs (perhaps even complete TLEs) can be managed. As postulated in several papers, this is supported in particular by the summary of documents to lectures, from lectures to courses and from courses to whole modules. The two general concepts (meta-objects and hierarchization) prove to be very interesting approaches with regard to the reusability of teaching materials or parts thereof in order to limit the effort described at the beginning for the recurring creation of new teaching materials. In addition, hierarchies can represent not only simple dependencies, but also more complex interrelationships and thus, have potential for detailed structuring. The respective authors also recommend the use of LOM standards.

Hierarchies in systems and models could not be found in the context of this paper. It is suspected that this integration has not yet been sufficiently investigated. However, since teaching materials are defined as being dependent on an IT system or a model organization, research should be carried out in this direction. In this context, an interesting aspect is the didactic shortening on different levels of the system or the model in order to make the knowledge transfer even more effective and real.

In general, dependencies and other metadata are very important in the context of this paper. They can help to structure TLEs, to describe their contents, to connect LOs with each other and to coordinate the ever progressing generation and preparation of knowledge due to specialization. The number of works examined in this context underlines the relevance and enormous importance over several years.

Around the years 2002 to 2007, more publications differentiate between the lecturer and the creator of teaching materials – in the context of this work the curriculum designer – and consider an exchange of several authors an advantage. Such a distinction would also be useful in the context of this paper. Consequently, materials can be exchanged between TLEs and also interdisciplinarity would be encouraged in the collaboration of authors from different fields. Furthermore, they can jointly create content (splitting of complexity) and identify errors more effectively in the course of a dual control and thus increase the quality of the entire TLE. This fact plays a special role in the concept of education service providers, since the use of the provided services depends on their perceived quality.

For the effective, continuous improvement of TLEs, the concepts examined can be used in the areas of feedback on LOs and annotations. Constructive feedback comes directly from lecturers or other curriculum designers to the creators of a teaching material. Both concepts offer the potential to support the work of curriculum designers.

Conclusion and Outlook

When faced with the challenge to design TLEs in system-based education, many issues arise that have to be solved for effective teaching. Based on expert interviews and a structured literature review, an overview about the problem fields is given. However, most of the related work attempts to solve individual problems in isolation. Consequently, there exists no holistic approach covering all identified aspects. More than half of all the works examined deals with e-learning. In contrast to the challenges motivated in this paper, this complex of topics includes the presentation and the distribution of learning content rather than the development of TLEs or the support of lecturers in the selection of teaching materials. Even though this work does not focus on e-learning, some concepts and ideas prove to be worth investigating for transfer or application to TLEs. Across all topics, concepts such as LOM standard, meta-objects, hierarchization and general reusability play an important role. They provide promising approaches for solving the problems identified at the beginning.

In further research work, the summarized concepts should be examined in detail within the scope of TLEs. Thereby, it can be evaluated which concepts can be applied or transferred to what extent to the topic of TLEs and which specific benefits they have. In addition, it is necessary to check whether several concepts can be integrated into a new, extensible meta-concept or whether an existing standard (e.g. LOM) can be adequately extended under certain circumstances. Such a comprehensive approach could solve several problems simultaneously. Furthermore, a central solution – assuming an easily implementable and usable meta-concept – would require less effort than the configuration or use of various individual solutions.

In further work with a technical reference, based on future theoretical investigations, a prototypical implementation of the meta-concept would be conceivable. As part of a pilot project, the effects for curriculum designers in the creation of teaching materials and for the lecturers in the selection of the same could be examined. By means of a comprehensive evaluation (gradually extended across different educational sectors and several domains), conclusions can be drawn on practical relevance and usability.

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