Fostering Comparability in Research Dissemination: A Research Portal-based Approach

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ABSTRACT
In this paper, we address the problem of lacking consistency and comparability in the dissemination of research information. We seek to solve this problem using research portals, which are community-based research information systems on the Internet. The idea of our solution is to customize research portals to better fit to individual application scenarios. To this end, we propose a conceptual specification of a generic portal structure allowing for semantic standardization. For a given application scenario, this basis has to be customized regarding portal structure and semantics of textual descriptions. We demonstrate such a customization for an exemplary research portal addressing design science research. Furthermore, we describe an exemplary research process using the customized portal definition. We conclude that our approach has the potential to increase the consistency and comparability of research dissemination with research portals. This goal is achieved with a) an individually customizable portal structure, which is able to reflect the nature of a specific application scenario better than generic structures and b) a semantic standardization of textual descriptions, which enforces them to be precise, compact, and apply the vocabulary of the domain.

Keywords
Research Dissemination, Research Portals, Unified Knowledge Representation, Current Research Information Systems (CRIS)

1. INTRODUCTION
Today, research processes are increasingly characterized by two potentially contradicting properties: competition and collaboration. First, researchers are players on a market where funding is provided by research funders. Researchers have to actively promote their research results in a kind of marketing behavior in order to prove their abilities to work on given problems and develop valuable solutions [27]. Thus, researchers compete against each other for scientific reputation to increase the chance of receiving future funding [29]. Second, due to the increasing complexity and interdisciplinary character of contemporary research problems, researchers often need to join forces and collaborate with each other [10, 18]. Again, they have to actively present their results to the broader audience to attract the attention of researchers from different disciplines and let them establish interdisciplinary research alliances, networks, or even new research organizations.

Research funders benefit from this situation as they are provided with better information on the potential funding receivers and their abilities in advance. Moreover, research funders, political decision-makers, and the public can gain a better picture of the research being conducted in certain domains. This way, they can identify emerging, established, and regressing topics and decide on the future funding policy [43].

Thus, different stakeholders need means to store and disseminate research results in a structured manner and to search for them effectively. Research portals are IT artifacts addressing this problem and providing a means for the dissemination of research information. They are Internet-based knowledge management instruments, which present research activities through answering different questions like “who is conducting the research?”, “what is being researched?”, “how is being researched?”, “what results have been achieved?”, and “who is paying for the research?” [26].

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An important issue in the design and application of research portals is the challenge of ensuring comparability and common understanding of their content. This problem addresses both the natural language and the structure of research information. Although different approaches like glossaries, tooltips, layout conventions, and description templates exist, they have not allowed to solve the problem so far [7]. Even if such description guidelines are present, users have to voluntarily follow them or the contents need to be subsequently standardized by a moderator, which can be costly. Our empirical study of 813 research portals showed that roughly 90 per cent of analyzed portals rely solely on a textual description of the application domain. We assume that the necessary common understanding is expected to emerge in the community itself. However, our own experiences gained while hosting research portals (e.g., http://www.forschungslandkarte-hybridewertschoepfung.de) showed that this assumption does not necessarily need to prove true. In our opinion, this is mainly caused by common reuse of contents available from other sources.

The goal of this paper is to address the problem of content comparability and comprehensibility in research portals. To this end, we propose an approach allowing for an individual context-specific definition of research portal structure as well as a specification of semantic standardization conventions for these structures. The approach is capable of a semi-automatic enforcement of these conventions in research portals. Thus, our approach fosters syntactic and semantic consistency of research portals contents allowing for more understanding in research dissemination.

The remainder of this paper is structured as follows. In Section 2 we present a literature review on research representation and discuss approaches allowing for a standardization of information. In Section 3 we present the conceptual foundation of our approach. An application example for research following the design science paradigm is discussed in Section 4. In the following Section 5, we discuss the advantages and disadvantages of the presented approach as well as it application limitations. In Section 6 we conclude with a brief summary and an outlook.

2. RELATED WORK

2.1 Research Portals

The general problem of information storage and dissemination is addressed by the research area of knowledge management, which elaborates on how to identify, gain, generate, disseminate, utilize, and retain knowledge [3, 31]. Knowledge management is of high importance not only for businesses but also in academic and research settings [45, 47].

Research portals support the creation of virtual communities of practice [36, 48] in research settings. Besides supporting internal communication in the community [50], a strong focus on reaching external stakeholders and fostering the knowledge transfer between practitioners and academics [41] is present.

Contrary to enterprise/corporate/knowledge portals [8, 12, 51], research portals do not act as repositories accumulating accessible knowledge on a topic, but rather point to original sources, what makes them similar to knowledge maps [46, 49]. They give a general overview of the involved parties, research topics, and achieved results trying to emphasize existing mutual relationships. These relationships can be of, for example, geographical, organizational, financial, or causal nature. Research portals can significantly reduce the effort put in the search for knowledge assets and the respective experts due to the structured – often visual – representation [15]. In Figure 1, we present an exemplary screenshot of a research portal (http://research.hopkinsglobal health.org/researchmap.cfm).

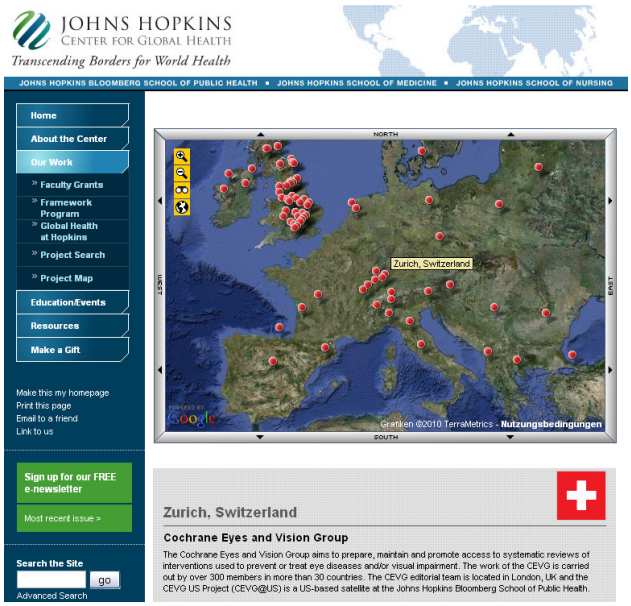

Figure 1.Example of a research portal

With the Common European Research Information Format (CERIF), a reference exchange data model for Current Research Information Systems (CRIS) data has been developed [25]. Its specification is disseminated in the form of a relational database schema, an XML schema definition, and database definition scripts. We present the main CERIF elements in Figure 2 as an Entity-Relationship Model (ERM) [11] in min,max notation [24]. The *Core Entities: Person*, *Project*, and *Organization Unit* can be interrelated and connected recursively to allow for the representation of common research organization structures. *Result Entities* represent the outcomes of conducted research and can be linked to *Core Entities* using *Link Entities* to document that, for example, a certain *Person* is author of a certain *Result Publication*. The authors decided to include three types of research outcomes: publications, products, and patents. In the semantics section of the CERIF specification, the authors provide concrete types of links between entities like author, participant, and supervisor. Thus, each link is typed using a predefined class.

The CERIF specification defines concrete attributes for each of its entities. These are represented by columns or tables of the database schema. For example, the attributes of a *Result Product* are shown in Table 1. We identify two limitations of this approach. First, the attributes are constant and cannot be customized for a concrete research portal without losing the conformity to the CERIF exchange standard. Second, a semantic standardization of entity descriptions is not addressed by CERIF. For example, for a product description, one large textual attribute is provided, the content of which is custom and can be chosen freely. With the approach presented in this paper, we tie in with these two issues and provide a means for a flexible development of customized description patterns and a semantic standardization of research information representation.

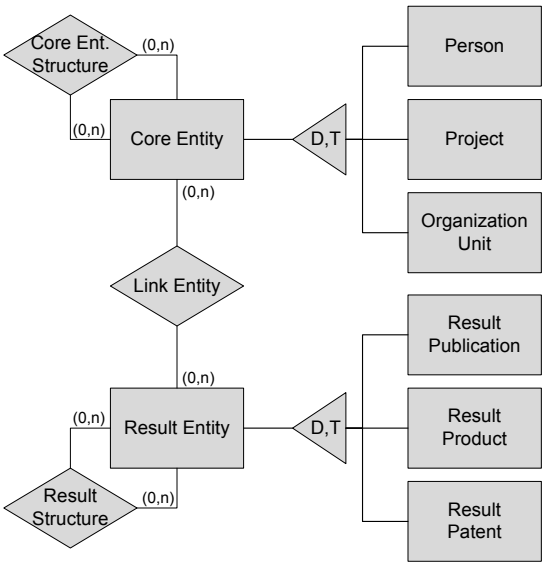

Figure 2. Main elements of the CERIF standard

With *yourResearchPortal.com* a software platform has been proposed which is capable of generating and maintaining multiple research portals [6]. Compared to the CERIF standard, the authors introduce the concept of a *research result* which acts as the central entity of a portal on their platform. They argue that the results of a research process are gained independently from their presentation in publications (e.g., one research result can be described in many publications). The authors address the problem of the comparability of research information representation by introducing ideas from the area of Business Intelligence to the field of research portals. In particular, they enable the definition of different dimensions for the classification of entities in the portal. The application of the same classification schema throughout a portal allows for conducting multi-dimensional analyses of the research information gained in the portal. However, the authors also include unstructured large text fields for the descriptions of research results, projects, and organizations, which are prone to the emergence of semantic ambiguities. These are, in turn, expensive to eliminate. The approach presented in this paper can be seen as a further development, which augments those large unstructured textual descriptions with semantic standards.

Table 1. Attributes of a *result product* in CERIF

Attribute	Type	Cardinality
Internal identifier	string	one
URI	string	one
Product Name	multi-language string	one per language
Product Description	multi-language string	one per language
Product Keywords	multi-language string	one per language
Publication	typed link	many per type
Organization	typed link	many per type
Project	typed link	many per type
Person	typed link	many per type
Funding program	typed link	many per type

2.2 Semantic Standardization of IT Artifacts

Unified knowledge representation has been a research problem existing for the last few decades. A number of approaches propose means for the resolution of ambiguous knowledge representation in different areas of application. They can be classified into two categories: Approaches deal with the problem either prior to the explication of knowledge (ex ante) or after it (ex post). Ex post approaches face the problem by analyzing existing knowledge representations, identifying ambiguities, and trying to solve them. Ex ante approaches aim at preventing the emergence of ambiguities by guiding the representation's author. As our paper deals with research portals, we focus on the explication of knowledge through *IT artifacts*, such as websites, wikis, databases and conceptual models.

Popular ex post approaches originating from the 1980s and 1990s address the resolution of ambiguities in IT artifacts related to the problem of database schema matching (cf. [39] for an overview). They analyze given schemas and identify possibly matching fragments. Further approaches do not take only single terms into consideration, like it is common in schema matching approaches, but also so-called *concepts* (e.g., [23, 14, 42]) These concepts consist of interrelated terms that are part of a domain ontology [20] and thus interconnected. These approaches have in common that existing IT artifacts (in this case: conceptual models) are connected to a domain ontology.

On the other hand, ex ante approaches focus on the avoidance of semantic ambiguities already during the construction of an IT artifact. They usually make use of conventions to limit the probability of using ambiguous terminology during the construction of IT artifacts in advance. Commonly, so-called naming conventions are provided as written glossaries, or as ontologies, which are suitable for the regarded domain. A general understanding of annotating IT artifacts (here: conceptual models) with ontological concepts is provided by [2]. Several approaches adopt terms or concepts from ontologies to use them in conceptual models [19, 9, 44, 1, 21].

Approaches related to linguistics provide standardized phrase structures as means for the generation of unambiguous denotations. Approaches related to conceptual modeling are presented by [40, 28, 33, 13]. [34] proposes an approach related to requirements engineering. [17] generate conceptual models automatically from natural language requirements descriptions.

To achieve semantic unambiguity in research portals, two aspects are crucial: First, compliance with semantic standards – either defined in an ontology or linguistically – has to be enforced. Thus, it has to be assured that users follow the standards while entering research information into the portal. Second, the semantic standards have to consider not only single terms, but also combinations of terms (either represented as complex concepts in ontologies or phrase structures to be instantiated with predefined terms), since sentences with a different order of terms may have different meanings.

The idea of our approach is to regard a research portal as a structured IT artifact that can be semantically standardized

analogously to a conceptual model. Therefore, we combine the idea of research portals with that of semantic standardization conceptual models. In particular, we favor the linguistic approach, as it is necessary to provide means for expressing syntactically correct sentences in a research portal rather than simple model element labels. Therefore, we reuse an approach that provides the user with a domain vocabulary and syntactic conventions restricting the possibilities of formulating sentences.

In our approach, conventions regarding vocabulary and syntax of textual descriptions have to be specified ex ante while defining the research portal, that is, before any contents are entered. During the process of entering research information into the research portal, the user is guided by a software wizard in order to assure compliance with the conventions [13]. Entered textual descriptions are parsed in the background and validated against specified conventions. Both the grammatical structure and the vocabulary are analyzed. If the provided description is considered valid, it is accepted by the portal system and the content can be persisted. Otherwise, the user is informed by the system about the violation and has to adjust the input. Exception handling routines are available so that content might be saved temporarily in case of insufficient conventions.

3. STANDARDIZATION IN RESEARCH PORTALS

In the following, we present the conceptual specification of our approach. It consists basically of two main concepts: a) the research portal structure definition and b) the semantic standardization definition, which are linked together (cf. in the following Figure 3). These two concepts allow for a) an individual definition of a concrete portal structure based upon a given application scenario and b) a context-based specification of semantic standardization conventions.

The central element of the conceptual basis for the specification of the research portal structure (cf. the black-shaded area in Figure 3) is the *Research Entity*. This concept can be seen as a generalization of CERIF entities [25]. It subsumes core entities representing the research environment (e.g., *Researcher*, *Project*, and *Organization*) as well as result entities, which cover the outcomes of research activities (e.g., *Publication* and *Research Result*). Additionally, research entities might represent further concepts (e.g., patents, products, goals, missions, and topics) staying in a defined relation to those mentioned. Research entities can be linked together building an *Entity Structure*. Every relation has a concrete *Relationship Type* like "is author of", "is part of", or "is result of".

We also include the concept of *Entity Classification* borrowed from [26]. To this end, multiple *Dimensions* can be defined, which subsume *Values* aligned in *Value Hierarchies*. The classification of research entities occurs by linking an entity to one or more values of a dimension. The definition of such dimensions allows for conducting multidimensional analyses of information accumulated in research entities and their structures.

For a research portal, it is crucial that research entities are provided with mostly textual *Descriptions* representing natural-language research information. In this approach, we seek to provide a means of standardizing (or restricting) the semantics of these descriptions. For this purpose, we introduce the concept of a

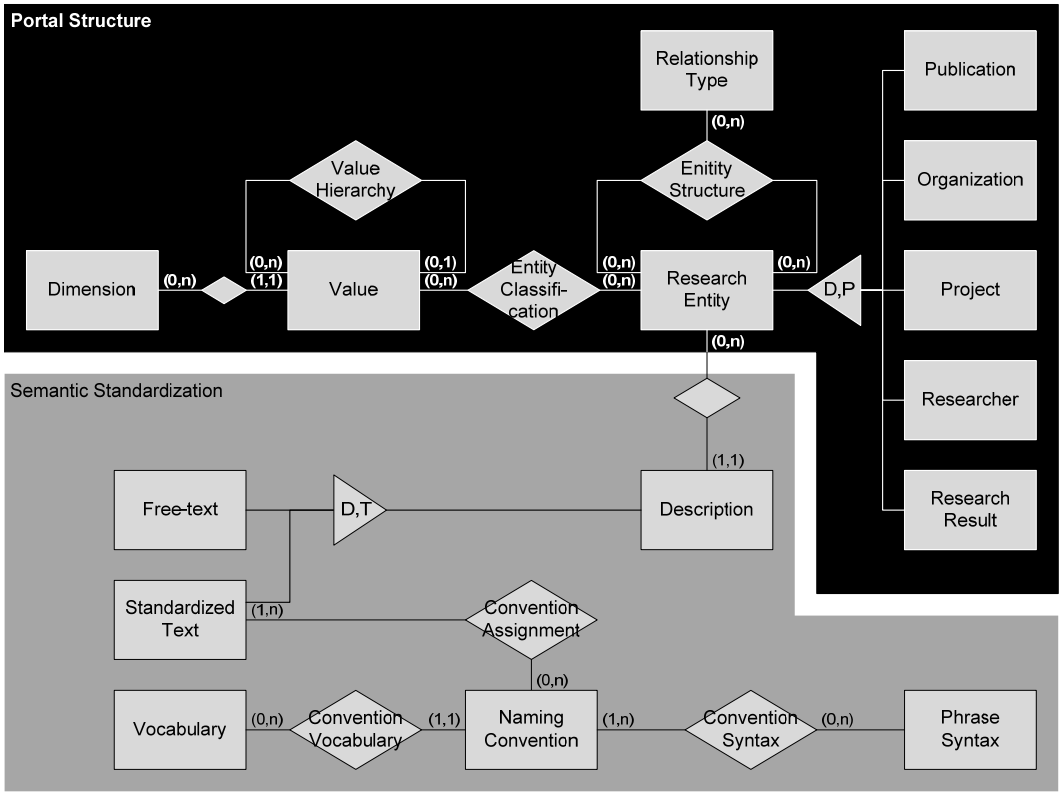

Figure 3. Conceptual specification of the approach

Standardized Text (cf. the grey-shaded area in Figure 3) being a specialized description. As we think that not every description can be semantically standardized, we also provide the construct of a *Free-text* representing a semantically unrestricted description. The semantic standardization of description is carried out by assigning one or more *Naming Conventions* to a description. The convention itself consists of two main components: a specific *Vocabulary* and one or more definitions of the *Phrase Syntax*. This way, we are able to restrict the applicable grammar of a description by controlling its main components lexicon and syntax. See [13] for details on this semantic standardization approach in the context of conceptual models. Here, we make the phrase syntax specification flexible to allow for both very concrete but also more general specifications. An example of the former is "<verb, present simple><noun, singular>" and of the latter "nominal phrase" or "affirmative present tense phrase". These phrase structure specifications have to be compatible to the linguistic parsers/taggers applied in the validation process. By the use of syntax restrictions, we try to control the granularity of descriptions. For example, if a goal has to be stated as a single nominal phrase, it has to be precisely explicated.

The conceptual foundation of our approach has to be individually customized based on a specific application scenario of a research portal to be developed. For the aspect of portal structure, this includes the concrete definition of existing research entities, allowed relationships, and their types. If needed, dimensions and values have to be specified as well. We think that, for example, the CERIF specification or the reference model for research portals [26] might be taken as a good starting point for this task.

For the aspect of semantic standardization, a portal customization includes the definition of one or more applicable vocabularies (i.e., repositories of allowed terms accompanied with meta-information) as well as the definition of allowed phrase structures. For the former, general-purpose repositories like WordNet [16] or the literature of the discipline might be a good starting point depending on the concreteness of a standardized text. For the latter, basic natural-language phrase definitions could be a basis to build upon.

4. APPLICATION EXAMPLE

We demonstrate the application of our approach with the example of design science information systems research [30]. The goal of this example is to show that, given a specific scenario, the customization of a research portal's structure and a semantic standardization for this scenario are feasible. We analyze a research process proposed for design science research and derive the structure and semantic standardization of a portal addressing research that follows this paradigm. This way, we configure a research portal which, in our opinion, better suits the needs of the design science research dissemination than a general-purpose one. We pick this research paradigm solely as an example while we think that analogous customizations are feasible for other application scenarios (e.g., paradigms and discipline cultures) of research portals as well.

The design science research process (DSRP) of [38] is a reference process model for design science research. It was inspired by a number of influential literature positions on design science from the past twenty-five years (e.g., [4, 32, 22]). The authors present their process model as a reference but state explicitly that researchers do not have to start from the first activity. Instead, they might start in the middle of the process and move outward. However, from the point of view of research process documentation and dissemination, it is not essential in which order the activities were carried out as long as their descriptions and outcomes are provided. Thus, we argue that the DSRP is a good basis for our example.

In the following, based upon the structure and discussion of DSRP activities, we derive research entities and their descriptions in standardized as well as free-text form. This is demonstrated in Figure 4. With dashed arrows, we link research entities to those concepts of DSRM which we derive them from. With solid lines, we associate descriptions to research entities.

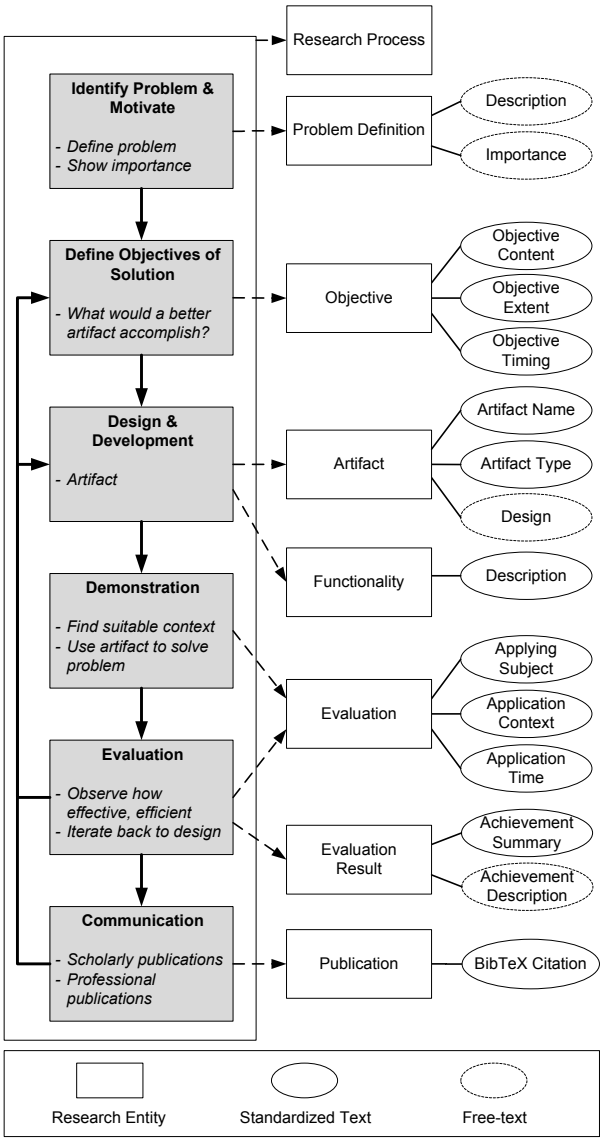

Figure 4. Deriving research portal structure and semantic standardization from DSRP

For a better comprehensibility, we present the derived allowed structure of the entities separately in Figure 5. There, we refrain from depicting concrete *Relationship Types* (i.e., their names) as

we describe them textually whereas presenting them would, in our opinion, reduce the readability of the model. For the sake of clarity and focused presentation, we also refrain from deriving dimensions and defining general vocabulary.

One of the goals of developing the DSRP was to "provide a mental model for presenting and evaluating design science research in information systems" [38]. Researchers are invited to structure their publications and presentations according to the process. Thus, we establish the research entity *Research Process* as a central result construct in the portal structure. When researchers present their design science research they talk about the research process. This entity acts as a container for succeeding more-detailed entities. The DSRP consists of six activities and we analyze each of them to find out which research entities with which descriptions would appropriately document these activities.

From the activity of problem identification and motivation, we derive the research entity *Problem Definition.* Here, researchers define the problem using a free-text Description and motivate its Importance using a free-text as well. As "it may be useful to atomize the problem conceptually" [38], these descriptions might have different individual structures and, therefore, we do not seek to restrict researchers too much by introducing semantic standardization for this research entity. In our opinion, a DSRP has exactly one problem definition. It is possible that more than one research process is triggered the same problem definition as multiple solutions can address the same issue in different ways.

The research entity *Objective* documents the activity "Define Objectives of a Solution", that is, represents a desired property (state) of a solution. This state is to be achieved in the DSRP. According to goal management in controlling literature, we divide the objective into three main components, which we think can be semantically standardized. First, *Objective Content* states what exactly is to be achieved. This can be expressed with nominal phases (e.g., "Increase of performance") or with affirmative present-tense statements (e.g., "Wireless communication is possible."). Second, *Objective Extent* describes how much of the goal content is to be achieved. This information can be explicated using a list of adjectives representing the extent. Finally, *Objective Timing* states when the goal is to be achieved. This description field can be standardized to include date/time values.

Based on the activity of artifact design and development, we derive two research entities *Artifact* and *Functionality*, which are interrelated with each other. An artifact is characterized by an identifying *Artifact Name* supporting its autonomous character. Names can be standardized as nominal phrases. Further on, artifacts are of a concrete *Artifact Type*. This description can also be semantically standardized. For example, [22] restricts the type list to four positions: construct, model, method, and instantiation. Thus, this field could be realized as a single-choice selection list. Finally, for each artifact the *Artifact Design* should be described meaning its inner structure (architecture). As research portals do not accumulate all accessible knowledge but rather point to original sources [46, 49], the design description should have an aggregated rather than extensive form. Nevertheless, we do not think that a semantic standardization would be feasible for this issue.

Each artifact is further characterized by at least one research entity *Functionality*. This is the dynamic counterpart to the rather structural aspect of an artifact design (architecture). The desired features of the artifact should provide a contribution to the achievement of the objectives. We think that functionality descriptions might be semantically standardized based on nominal phrases.

From the two activities of demonstration and evaluation, we derive only one research entity *Evaluation* as both activities are not autonomous and depend on each other. First, a demonstration of an artifact application with no critical analysis of its contribution to the objectives merely shows that an artifact *can* be applied but not that it actually solves the problem by reaching the objectives. On the other hand, an evaluation without preceding demonstration is not possible. Without the knowledge that an artifact achieves the objective content, we cannot measure the extent of objective achievement. If more than one artifact is developed in a DSRP, each of them has to demonstrated and evaluated. However, an evaluation might be conducted for multiple artifacts at one time (cf. Figure 5).

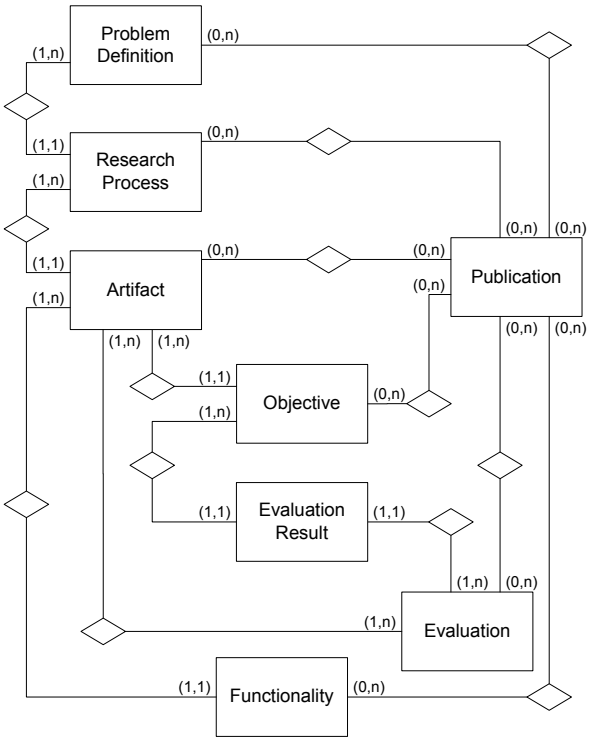

Figure 5. Relations between research entities based on DSRP

The research entity *Evaluation* is characterized by three semantically standardized descriptions. The *Applying Subject* is a single nominal phrase denoting the person or group of persons who apply the artifact. *Application Context* describes the particular purpose of the application (i.e., answers the question "why does the subject apply the artifact?") by the means of a single nominal phrase. Thus, the application context is a concrete instantiation of the general problem definition which the applying subject is facing. *Application Time* denotes the span of time when the application took place.

Based upon the activity of evaluation, we derive the entity *Evaluation Result*, which is directly related to one of the previously defined objectives as well as to a concrete evaluation. An evaluation result describes to what extent an objective was

achieved in the evaluation. We propose two characterizing descriptions: a semantically standardized *Achievement Summary* for a brief statement on the extent of objective achievement and a free-text *Achievement Description* for additional explanations.

Finally, the last activity in the nominal DSRP is the communication of the conducted research in both research and professional community. From this activity, we derive the research entity *Publication*, whose description is standardized using a *BibTeX Citation* [37]. We chose BibTeX as it is widespread in the research community and can be mapped to other notations using accessible tools. Researchers are prompted to communicate "the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness" [38], that is, the DSRP as a whole and the outcomes of individual activities. To this end, we allow for relating publications to all derived research entities (cf. Figure 5).

To demonstrate the practical feasibility of this derived research portal structure and semantic standardization, we apply it to describe an existing DSRP. For the purpose of such an exemplary demonstration, we picked up the research process of designing *yourResearchPortal.com* based on [6]. Three authors of this paper also participated in that research process. See Table 2 for details. Descriptions which are not semantically standardized are written in italics.

Table 2. Standardized description of the DSRP of *yourResearchPortal.com*

Research Entity / Desription	**Contents *(phrase syntax)***
Problem Definition	
Description	*Research portals help to countervail the disadvantages of specialization in research. The creation and maintenance of a research portal requires not only domain knowledge but also thorough IT skills.*
Importance	*Enabling IT-unskilled researchers to create functional research portals is required for a widespread application of research portals.*
Objective 1	
Objective Content	Researchers are able to generate research portals. *(affirmative present-tense statement)*
Objective Extent	easy, fast *(list of adjectives)*
Objective Timing	n/a *(date/time value)*
Objective 2	
Objective Content	Generated research portals realize five introduced core functions. *(affirmative present-tense statement)*
Objective Extent	full *(list of adjectives)*
Objective Timing	n/a *(date/time value)*
Artifact	
Artifact Name	yourResearchPortal.com *(nominal phrase)*
Artifact Type	instantiation *(noun; restricted selection)*
Design	*The system consists of two main components. The data administration component is realized using the CMS Drupal. The data analysis component is realized using the OLAP engine Mondrian. Both components operate on the same database structure and are integrated in one GUI.*
Functionality 1	
Description	Easy and fast generation of research portals *(nominal phrase)*
Functionality 2	
Description	Maintenance of multiple portals on one site *(nominal phrase)*
Functionality 3	
Description	Multidimensional analyses *(nominal phrase)*
Evaluation	
Applying Subject	Authors *(nominal phrase)*
Application Context	Creation and maintenance of a research portal for service science *(nominal phrase)*
Application Time	n/a *(date/time value)*
Evaluation Result 1	
Achievement Summary	full *(adjective; restricted selection)*
Achievement Description	*Easy and fast generation of research portals is possible "at the push of a button".*
Evaluation Result 2	
Achievement Summary	partial *(adjective; restricted selection)*
Achievement Description	*The core functions one to four are fully supported. The fifth core function is partially supported. Better discussion support is needed.*
Publication	
BibTeX Citation	`@inproceedings{Becker2010, author = {Becker, J. and Knackstedt, R. and Lis, Ł. and Stein, A.}, title = {Entwicklung und Anwendung eines Internetwerkzeugs zur Generierung von Forschungsportalen}, year = {2010}, booktitle = {Multikonferenz Wirtschaftsinformatik (MKWI 2010)}, note = {Göttingen} }`

The example shows the practical applicability of the structure and semantic restrictions derived from DSRM. All descriptions besides those referencing time information could be found in the source publication and expressed using the given structure. It was somewhat challenging to decide on semantically standardized

descriptions like objectives and functionalities as one has to build a mental model of the conducted research based on the accessible documentation and memorized experiences. However, in our opinion this enhanced the quality of representation as statements need to be precise and comply with semantic restrictions. Even though the phrase structure specifications are mostly rather unrestrictive (e.g., "nominal phrase"), they allow for controlling the granularity of descriptions. For example, specifying the objectives as single affirmative present-tense statements along with their expected extent in form of adjectives seems flexible enough to allow for a convenient description but restrictive enough to have impact on the granularity and quality. In this example, we do not make excessive use of lexical conventions as we cannot identify a domain vocabulary for design science research. This should be possible for research portals organized around a certain narrow topic.

Summarizing, the derived portal definition enforced the whole description of the research process to be structured, explicit, and compact. Moreover, a direct relation to the nominal DSRP process could be established. On the other hand, the derived structure and restrictions made the task of describing a research process more time-consuming as simple data reuse techniques (e.g., copy & paste) are generally not applicable.

5. DISCUSSION AND OUTLOOK

The work presented in this paper addresses the problem of ensuring consistency and comparability in research dissemination. We seek to solve this problem using research portals, which are customized to individual application scenarios. To this end, we propose an approach consisting of a conceptual specification of a generic portal structure along with its enhancement allowing for a semantic standardization of textual contents. For a given application scenario, this conceptual basis has to be customized by defining the specific portal structure and concrete semantic standardization restrictions. We demonstrate such a customization for a research portal focusing design science and further show how research information could be represented in this customized portal by describing an exemplary research process.

We conclude that our approach has the potential to increase the consistency and comparability of research dissemination with research portals. This can be realized by a) an individually customizable portal structure, which is able to reflect the nature of a specific application scenario better than generic structures and b) a semantic standardization of textual descriptions, which enforces them to be precise, compact, and use the vocabulary of the domain. Furthermore, the extensive use of semantic standardization in research portals allows researchers for connecting different portals more easily. Through the explicit specification of the necessary domain vocabularies, it becomes possible to align these with the goal of portal interoperability, even if they originate from different research disciplines.

On the other hand, our approach requires more effort than generic ones (e.g., those exactly following the CERIF standard) in the design phase of a portal as well as during the description of research entities. We argue that these higher costs of use result in a higher quality of the research representation. However, this assumption requires a thorough evaluation. To this end, several steps are scheduled. First, we want to test the research portal structure customized for design science in the preceding section using multiple design science research processes. Good candidates might be the examples of research processes analyzed in [22, 38]. Second, we are going to validate our general concept by customizing portals for multiple application scenarios. To realize this, we are currently working on an implementation of the presented approach in a research portal system. We base the system upon a common content management system (CMS) supporting a flexible definition of content types (research entities and descriptions). We extend the system by allowing for the specification of semantically standardized fields. Moreover, we bind linguistic tools for on-the-fly data validation. Finally, with a completed implementation we will be able to conduct empirical analysis on the cost-benefit ratio of our approach in real life portal settings. We expect that approach is particularly useful in smaller individual application scenarios contrarily to mass-scale research portals, which rather lack individual structural and semantic characteristics. Moreover, as we expect our approach to increase the transparency in research dissemination it might be interesting to analyze its acceptance. In particular, some stakeholders might fear changing the status quo.

In future research, several issues need to be discussed. First, as our approach can be seen as a further development of the CERIF standard, it has to be analyzed in how far it is still compatible with the data exchange reference model. We expect that individual data mappings will have to be established. Second, the compatibility of our work with automated data collection approaches like data harvesting [5, 35] needs to be proven. This might be particularly advantageous regarding the bibliographic aspect. Third, as we implement our approach in a generic CMS, it will be in our opinion interesting to investigate how our approach might be useful in general content management settings not related to research information. Finally, an interesting research outlook is the semantic standardization of large textual fields incorporating multiple sentences.

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