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Towards a Maturity Model for Research Portals

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TOWARDS A MATURITY MODEL FOR RESEARCH PORTALS

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Abstract

Research portals are websites that present information about certain research activities and their corresponding results in a structured manner. Institutions like universities, businesses, or governmental organizations use them as knowledge base to identify and communicate “who researches on what” or “where can the relevant information, people, or funds be found”. Furthermore, such portals are increasingly used as a marketing measure to manifest own research positions and compete against others for resources and reputation. However, research portals differ in their range of functionalities regarding their target audience and current development state. In this paper, we develop a maturity model for research portals according to a well-founded procedure model. We evaluate our maturity model on the sample of 287 real-life research portals and provide selected analyses as well as interpretations regarding the model’s feasibility. We conclude presenting promising directions of further model development and opportunities of transfer into practice.

Keywords: Maturity Model, Knowledge Management, Portals

1 ON THE IMPORTANCE OF RESEARCH PORTALS

Comparable to the free enterprise economy, where companies are in competition with each other in certain segments, research institutions are players on a market for financial support provided by research sponsors. On the one hand, research organizations, networks, or even individual researchers have to 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 (Krücken & Meier 2006). Furthermore, they advertise their research results to let them be found by possible research partners. As interdisciplinary research is increasingly appreciated by research funding organizations, means are needed to attract the attention of researchers from different disciplines (Schimank 2005). Research sponsors, on the other hand, benefit from this situation as they can inform themselves about the potential fund receivers and their abilities in advance. Moreover, they can gain an impression about research being conducted in certain domains, thus having information at hand that might help them to decide on the area of research they would like to fund in the future.

Accordingly, researchers and sponsors need means to persist and present research results in a structured manner and to search for them effectively. This problem is addressed by the research area of knowledge management, which elaborates on how to identify, gain, generate, disseminate, utilize, and retain knowledge (Probst & Raub & Romhardt 1999). Knowledge management is not only a success factor in business but, as motivated here, also of highest importance for researchers, research networks, and organizations.

Research portals serve as means for the dissemination of research results and as marketing measure for research institutions. 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?”, “what results have been achieved?”, and “who is paying for the research?”. Research portals give a general overview of the involved parties, research topics, and achieved results trying to emphasize existing mutual relationships. These relationships can be, for example, of 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 (Eppler 2001). Additionally, they support researchers lacking the opportunity to present their research results to larger audiences (e.g., by attending to conferences, congresses, or fairs) due to economic or geographic circumstances (e.g., researchers from developing countries).

Although a reference model for research portals already exists (Knackstedt et al. 2009), a further measure for conducting the assessment of a given portal is still needed. This is the point where maturity models come into play. They serve as means for analyzing, comparing, and improving certain aspects of the regarded domain (de Bruin et al. 2005). This can either be done by external maturity consultants or in terms of a self-assessment. We argue that a maturity model for research portals would provide a useful measure for improving the efficiency of research dissemination on the one hand and the accessibility of research solutions on the other hand.

The development of the maturity model is guided by the following three research questions:

- (R1) Which dimensions should be considered for describing research portals?
- (R2) Which functionalities exist to operationalize these dimensions?
- (R3) To which maturity levels can these functionalities be mapped?

To answer these questions and to develop the maturity model for research portals, we decided to take advantage of a procedure model for developing maturity models. The paper presents the application of the procedure model including both development and evaluation.

2 METHODOLOGY

Maturity models have recently gained much popularity in both research and consulting communities. Not surprisingly, de Bruin et al. (2005) counted more than a hundred models of this type. However, authors seldom reveal the motivation and the development process of their models. To anchor the development of our maturity model for research portals in a solid fundament, we seek to employ a transparent yet strict procedure model. Contrary to the large number of maturity models being developed, the research on their development is relatively rare. In our literature review, we encountered two serious contributions. First, de Bruin et al. (2005) aim at introducing the missing methodology by describing a phase model consisting of six steps. The authors applied the proposed approach in the development of at least two maturity models in the domains of Business Process Management (Rosemann & de Bruin & Power 2006) and Knowledge Management (Freeze & Kulkarni 2005). Second, Becker, Knackstedt, and Pöppelbuß (2009) propose a flowchart-oriented procedure model consisting of eight phases interconnected by decisions and control flows. Their approach is based on the seven guidelines for design science proposed by Hevner et al. (2004) with regard to later critical complements by Zelewski (2007). The authors analyzed available development documentation of 51 maturity models and chose six, which were most extensively documented. These also contain the model of Rosemann, de Bruin, and Power (2006), thus the procedure model of Becker, Knackstedt, and Pöppelbuß can, to some extent, be seen as a design science-influenced extension and further specification of the phase model proposed by de Bruin et al. (2005).

For the purpose of developing our maturity model for research portals we implement the procedure model of Becker, Knackstedt, and Pöppelbuß (2009), mainly because we appreciate its anchorage in design science and the strictly implemented postulate of scientific documentation. In Figure 1, we present our slightly customized version of this model. In place of the originally very detailed input/output documents, we annotate development phases with sections of this paper where the respective inputs and/or outputs can be found.

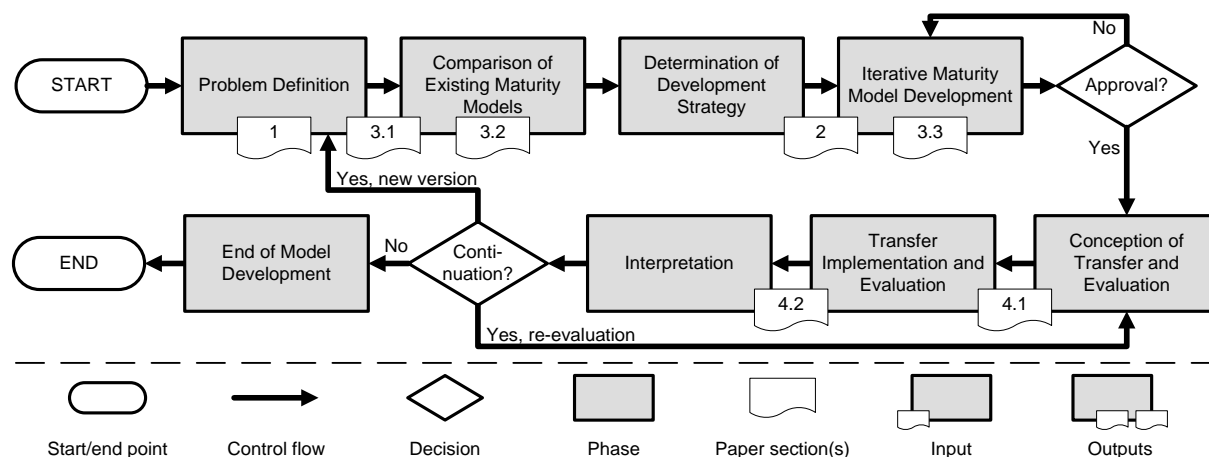


Figure 1: Procedure Model Followed during the Maturity Model Development (adapted from Becker & Knackstedt & Pöppelbuß 2009)

Our procedure model starts with a problem definition. Here, we range the domain scope of the maturity model and discuss the target group. Moreover, we outline application conditions as well as its intended benefits. Thus, we motivate the need for a maturity model for research portals. This motivation of our proposed artifact is documented in the preceding section of this paper. In Section 3.1 we provide a more detailed scope and target discussion. This output of the first phase is, at the same time, the input of the succeeding phase of the comparison of existing related maturity models, as this has to be conducted with a specific scope in mind.

In the second phase, we conduct a literature review to identify existing maturity models devoted to the same or similar domains. We analyze them carefully looking for dimensions and functionalities that

are relevant to our domain. Then, we determine the development strategy of our maturity model. We decide how the previously compared models can be reused and which procedure we are going to follow during the next central phase of the iterative model development. Here, we design and test the structure and content of the model in a step-by-step manner according to the chosen approach until the results are satisfactory. This process and its outcome are described in detail in Section 3.3.

Having completed the first design phase of our maturity model, we need to determine how the model is to be transferred to the user community. We discuss different application scenarios and corresponding transfer media as well as modes of internal and external evaluation. In Section 4.1, we establish a concrete transfer and evaluation strategy for our maturity model. Having implemented the chosen approach, we collect and analyze empirical quantitative data. We present the results in the following section along with their interpretation serving as basis for the decision on further development of our maturity model.

3 CREATION PROCESS OF THE MATURITY MODEL

3.1 Problem Definition

Research portals in our sense will be defined as follows: They are (1) topic related (2) websites, (3) specifically structuring information which (4) already exists elsewhere. The main goals of research portals in our sense are (5) the fostering of collaboration between research projects and (6) the promotion of research artifacts which are being or have been developed.

To reach these goals, the research portal provides means to document *who* conducts the research in *which research projects* and *which results* should be or have been developed. Thus, the websites links individual researchers or research institutions with certain artifacts. We tried to limit the amount of relevant websites by defining six prerequisites.

(1) We consider websites as research portals if they are dedicated to a certain matter. This can, on the one hand, be domain-oriented (e.g., stem cell research, research on renewable energy, or research on insects). On the other hand, research portals may offer information about research results provided by either a closed but topic-spanning community of researchers (e.g., research portals of universities) or a geographically restricted group of researchers (e.g., research portal of the German state Saxony-Anhalt, <http://www.forschung-sachsen-anhalt.de/>). This perimeter has to be explicitly stated or communicated by the portal.

(2) We only consider those research portals which exist as websites. The way in which the information is stored and presented (i.e., the technical implementation of the website) is irrelevant. Thus, libraries or printed collections of research results are not being considered.

(3) The website providing the before mentioned information may – but does not have to – provide the original research artifact itself. However, a link to the original artifact should be made available. If this is not possible (e.g., due to copyright restrictions), either a link to the original source (like the project website) and/or at least a short descriptive text should be provided.

(4) The website provides the information about the research results in a structured manner, depending on the developer's intended objective. For example, the artifacts may be presented geographically structured on a map, using a tag cloud, or by simply alphabetically ordering the artifacts. The level of detail and the amount of variations in which a research artifact can be described depend on the expected quality of a research portal.

(5) We not only consider research being conducted by academics at universities or other national research institutions, but also research being conducted by companies or public administrations. Whether or not a portal is relevant for our study does not depend on the way the research is financed.

(6) The website has to provide means for supporting and spreading the research results by raising their level of awareness. This awareness is an enforcing prerequisite for enabling the initiation of coopera-

tion between research projects and the further utilization of external artifacts. This might either be the incorporation of external research artifacts in your own research process, or it might be the external evaluation and mutual improvement of existing research artifacts. It is, however, unimportant whether the website was explicitly developed for this purpose in the first way. Instead, it needs to be recognizable that the website can be used for this purpose. Another premise is the absence of commercial intentions. Having defined our research scope, the following subsection describes the way towards the decision of developing a new maturity model for research portals.

3.2 Comparison of Existing Maturity Models and Definition of Development Strategy

Before analyzing existing maturity models, we chose the Reference Model for Online Research Maps by Knackstedt et al. (2009) for identifying relevant functionalities a website can hold and clustering them into twelve dimensions of interest (cf. Table 1, dimensions 1–12).

Online Research Map Reference Model		eGov MM	Knowledge Management MM	Business Process MM	Portal MM	Intranet MF
Knackstedt et al. (2009)		Windley (2002)	Ehms & Langen (2002)	Rosemann & de Bruin & Power (2006)	de Carvalho (2005)	PBworks (2008)
1	<i>Feature:</i> Research Project, Research Result / Institute, Publication		<i>Feature:</i> Knowledge Structures, Knowledge Forms		<i>Feature:</i> Information Sources	
2	<i>Feature:</i> Information on Research Area				<i>Dimension:</i> Taxonomy	<i>Dimension:</i> Enterprise-wide Taxonomy
3	<i>Feature:</i> Search Engine, Research Map	<i>Feature:</i> Lists			<i>Feature:</i> search engine (RM)	
4	<i>Feature:</i> Become a Member				<i>Feature:</i> Content Management	
5	<i>Feature:</i> Analyses			<i>Feature:</i> Process Metrics, Process Output Measurement	<i>Feature:</i> Business Intelligence	<i>Feature:</i> Performance indicators
6	<i>Feature:</i> Cooperation Forum, User Feedback, Recommend Site, Event Calendar,	<i>Dimension:</i> Cross-departmental Sharing of Information	<i>Dimension:</i> Collaboration, Partnerships	<i>Dimension:</i> Culture	<i>Dimension:</i> Collaboration	<i>Feature:</i> Calendars (RM), Contacts (RM), Discussion Databases, Web Conferencing, Teamware, Corporate Instant Messaging, User-driven Ratings
7	<i>Feature:</i> News, Press Releases				<i>Feature:</i> Alerts	
8	<i>Feature:</i> FAQ, Help Texts, Sitemap	<i>Feature:</i> Online Help (RM), FAQs (RM), Web-based Training (RM)		<i>Feature:</i> Process Education, Learning	<i>Dimension:</i> Training	<i>Dimension:</i> Training (RM)
9	<i>Feature:</i> Sponsoring, Funding, Job Vacancies					
10	<i>Feature:</i> Link Collection	<i>Dimension:</i> Business Process Integration			<i>Dimension:</i> Workflow	
11	<i>Feature:</i> Membership		<i>Feature:</i> Roles	<i>Feature:</i> Process Roles	<i>Feature:</i> User Accounts, Rights Management	
12	<i>Feature:</i> Change Language					
13		<i>Dimension:</i> Configuration			<i>Dimension:</i> Personalization	<i>Dimension:</i> Personalization, Customization

Table 1: Evaluation of Existing Maturity Models and Validation against Reference Model

We used those to compare the dimensions and functionalities provided by the existing maturity models with the reference model. If one of the existing maturity models provides sufficient compliance with the functionalities and/or dimensions required, the development strategy will point towards an advancement of this model. Otherwise, the development of a new maturity model will be considered.

Several maturity models exist concerning websites or online portals. However, they originate in different areas of interest. Table 1 illustrates how the different maturity models prove themselves in regard to the reference model. Column 1 lists a set of functionalities of the reference model, which were clustered to the dimensions listed in column 2. The dimension “Information” for instance describes the content available in research portals, the dimension “Common Understanding of Terms” specifies features that help users come up with a map-wide understanding of certain technical terms, etc. These dimensions were mapped to existing maturity models which had to meet two criteria. First, their development process had to be reasonably well documented and, second, their respective domains had to be comparable to the domain of research portals. An extensive online research revealed the five ma-

turity models depicted in the first row of Table 1. The *E-Government Maturity Model* (eGovMM) by Windley (2002) describes maturity levels for websites of public administrations. The *Knowledge Management Maturity Model* (KMMM) was developed by Ehms and Langen (2002) at Siemens. It provides companies with an evaluation of its knowledge management capabilities. The *Business Process Maturity Model* (BPMM) by Rosemann, de Bruin, and Power (2006) assigns maturity levels to the process management of a company. De Carvalho's, Ferreira's, and Choo's (2005) *Portal Maturity Model* (PMM) defines maturity levels for web based portals. The *Intranet Maturity Framework* (IMF, PBworks 2008) evaluates the features of a company's intranet.

Each maturity model defines certain dimensions of features for its respective domain. Depending on the level of documentation of a given maturity model, either more abstract dimensions or very specific features could be ascertained. These dimensions or features are depicted in the cells of Table 1. In doing so, the maturity models' characteristics are mapped to the feature dimensions of the reference model for research maps to find out if there are other dimensions yet unacknowledged by the latter. Only the *Customization* dimension (No. 13) was provided by several maturity models but not by the reference model. Thus, we included it in our dimension scope. After having mapped the maturity models against the reference model, we conclude that we cannot identify any further relevant feature dimension to describe a maturity model for research portals.

Naturally, none of the maturity models analyzed provides exactly the focus that we desire. Hence, as none of the regarded maturity models is able to cover all functionalities required for our purpose, we decide to develop a new one. Considering its functionalities and levels, the PMM however fits best to our maturity model and shall serve as orientation for the development of our maturity model.

3.3 Iterative Maturity Model Development

First iteration: Five levels of maturity

As a starting point, we propose five levels of maturity; however, they might be subject to change if the iterative development of the model should indicate it. Each portal should be at least member of level one, due to the fact that it has been covered in our analysis and already fulfills the basic criteria. Functionalities that support the interactive search for projects and their respective locations will raise the maturity of a portal one step to level two. Functionalities pointing towards level three of our maturity model extend the before mentioned ones by offering the opportunity to interact with the portal. This might be providing means to add new results, comment on existing ones, or support community building by offering memberships. Level four of maturity can be reached by offering functionalities like structured analysis of research results, by being able to acquire sponsors for the portal, or by providing functionalities which are state of the art in actual web 2.0 scenarios like Twitter feeds, social network integration, etc. The highest maturity can be reached by, for example, automatically integrating content of other (not necessarily research) portals, providing means to dynamically configure the portal to the user's needs or by providing interfaces in a way that others might push information into the research portal.

Second iteration: Selection of functionalities

To rate portals in terms of maturity, we selected 13 *dimensions*, derived from the research map reference model (again, cf. Table 1). Each dimension can be described by certain functionalities, while each *functionality* can be assigned to one maturity level. Table 2 exemplarily illustrates certain relations between functionalities and their dimensions. Those relations were initial believes of the authors that were discussed with several members of the research team and seemed to be reasonable. However, like the maturity levels, they are subject to change during the evaluation of the maturity model. Most of these functionalities originate from the reference model as well as from the PMM.

	Maturity Level 1*	Maturity Level 2	Maturity Level 3	Maturity Level 4	Maturity Level 5
Information	Organisation, Scientist, Solutions	Assignment Scientist to Organisation	Assignment Solution to Research Problem	Assignment Solution to Organisation	Relationship between Solutions
Common Understanding of Terms		About this Site / About Us	Glossary	Help Sites for Technical Terms	Discussion Forum
Search for Content		(alphabetical) List, Search Engine	Tag-Clouds	Knowledge Map	Search Engine based on Recommendation
Gathering of Content		Web Links	File Upload, Templates		
Quantitative Analysis		Static Tables	Static graphs	Dynamic Tables	Dynamic Graphs
Collaboration		E-Mail Address or Contact Form	Rate content, comment on content, blog	Chat, Video Conferencing	Cooperation Forum
Notification		Newsletter	List of latest entries	RSS-Feeds	Customizable Newsletter
Training		Sitemap	FAQ	Help Texts	
Commercialization		Mention of Sponsors	Invitation to Donate	Advertisement	Article or Book Sale
Process Integration			Links to similar Sites		Access to Content of other Research Maps
Administration		Free Access	Registration / Membership	User Profiles	
Multi-language Support			Multilanguage Support of Portal infrastructure		Multilanguage Support of Content
Customization		Customizable Display of Content	Behaviourbased Display of Content	Choice of Skins	

* Every portal being considered by our analysis is at least rated maturity level 1. Thus, no functionalities despite *Information* exist for level 1.

Table 2: *Exemplary Functionalities and their Respective Maturity Level*

For this, we developed a web-based tool, providing the respective means. During the evaluation of the questionnaire with ten volunteers (which were not related to the project), it became apparent that the questions were not formulated clear enough, thus making it hard for users to understand their intentions. Furthermore, the time required for answering the questionnaire was too extensive. Hence, we revised them, making it easier for the volunteers to answer, therefore reducing the time required for filling it out.

Third iteration: Generation of questionnaire

During this iteration, it has to be decided how to transfer the maturity model into practice. Besides the application as means for consulting purposes, a very promising idea is to provide means for self-assessment. In this scenario, users or portal operators are given various resources allowing them to assess a certain portal themselves. Common possibilities are the provision by print (e.g., brochure, handout, or PDF-download) or directly by a questionnaire. Thus, users are able to assess the maturity of a certain research portal by answering simple questions. The chosen answers, which are related to functionalities (again, cf. Table 2), are then rated with their respective maturity level. Here, we decided to develop an easily accessible web-based questionnaire.

4 EVALUATION

4.1 Conception of Evaluation

In order to evaluate the usefulness of our maturity model for the assessment of research portals' maturity, we need to implement it in a real-life setting and prove whether the model provides the projected benefits. For this purpose, our aim is to apply the model to a substantial number of existing research portals and evaluate its applicability and the feasibility of the collected results. In the first step, it is necessary to establish an extensive test sample of research portals. Here, we decided to employ the web search service of Google (<http://www.google.com>).

In order to determine a well-founded search strategy, in March and April 2009 we conducted a preliminary, exploratory study on the terms suitable for searching research portals with Google search. In a web-based survey, we provided our definition of research portals and asked for terms the respondent would use to search for such websites using Google. We integrated a Google search component in our

survey form and were able to provide interactive results for the given terms. The respondents could then rate the actual usefulness of the returned results and provide further search terms if necessary.

We received a response from 102 researchers from the domains of information systems and business administration. The analysis of the collected data shows that 73 % of the proposed search phrases consist of two terms. The first term specifies the research context and the second one provides the class of objects searched. We identified four most frequent words in each position (cf. Table 3). For the purpose of the final search, we combined each term in the first position with each term in the second position resulting in 16 search phrases.

First Search Term (Context)	Second Search Term (Object Class)
Research, Knowledge, Science, Know-how	Portal, Map, Directory, Database

Table 3: *Phrases Commonly Used to Search for Research Portals*

Each search phrase was submitted to Google web search twice between June 29th and July 1st 2009 in order to compensate local variations in returned results. In total, we registered 20,649 hits resulting in 13,044 distinct URLs. Each of them was then manually analyzed whether it leads to a website being a research portal according to our definition presented in Section 3.1. Despite of our rather general search terms, we believe to have found most relevant portals in this second manual phase. This way, 983 research portals were identified. Exemplary excluded websites consisted of: (a) business websites aiming at marketing certain products or services, (b) universal search engines, (c) not domain-oriented e-libraries or blogs, and (d) university websites providing only general information and no actual research data.

In the next step, we randomly ordered the 983 portals identified using the Mersenne twister pseudorandom number generator (Matsumoto 1998). Then, one researcher under supervision of the authors analyzed the first 136 random research portals and applied our maturity model by filling out the web-based questionnaire described in Section 3.3. We discussed the applicability of the maturity model and analyzed the quantitative data collected in this evaluation iteration. It became clear that some adjustments to the assignments between functionalities and maturity levels were desirable. For example, as only very few portals offered multi-language infrastructure, we discussed this functionality again and decided to shift the assigned maturity level from three to four. Such corrections took place in six cases. Furthermore, the phrasing of the questionnaire was slightly improved. As general model applicability was given and the results were promising, we decided to proceed with the evaluation.

We analyzed the next random sample of 151 research portals and assessed their maturity. Hence, up to now we have applied our maturity model to 287 real-life research portals. In the next section, we present selected quantitative analyses providing insight into the data collected so far. We interpret the results regarding the feasibility of our maturity model and finally decide on its further development and transfer into practice.

4.2 Evaluation Results and Interpretation

In order to provide some information on the data and enable general understanding, for each research portal we recorded two basic facts. First, we identified the domain the portal is devoted to. Here, we differentiate between six most common domains, other ones, and portals, which are limited to a closed community of researchers but not a single research topic (cf. Table 4). A typical example of the latter case is a topic-spanning research portal of a university. Second, for each portal we identified the entity being the operator (i.e., usually initiator and administrator) of the portal. Here, we differentiate between seven general types of portal operators (cf. Table 5). In our opinion, the results show that the implemented search and random sampling strategy provides reasonably differentiated evaluation samples.

Portal Domain	# of Research Portals
Technology	51
Medical science	50
None	43
Environment	38
Natural science	37
Other	28
Economics	25
Education	15

Portal Operator	# of Research Portals
University	70
Private research organization	66
Public research organization	54
Research network	46
Governmental organization	20
Business	19
Journal	12

Tables 4 and 5: Distribution of Assessed Research Portals with regard to Domain and Operator

In the next step, we tried to evaluate whether our maturity model covers and depicts a sufficient degree of variability of real-life research portals. For this purpose, for each research portal and each of the 13 dimensions we aggregated the maturity levels assigned to the functionalities grouped in a given dimension resulting in one level per portal and dimension. Here, we decided to choose the maximum maturity level in a dimension, as in our opinion this best depicts the maturity achieved by a portal in this dimension. In Figure 2, we present a radar chart depicting the minimum and maximum maturity level in each dimension as well as the upper median. The cover range of the model seems to be generally satisfactory. However, in case of a few dimensions further changes to the model might be necessary.

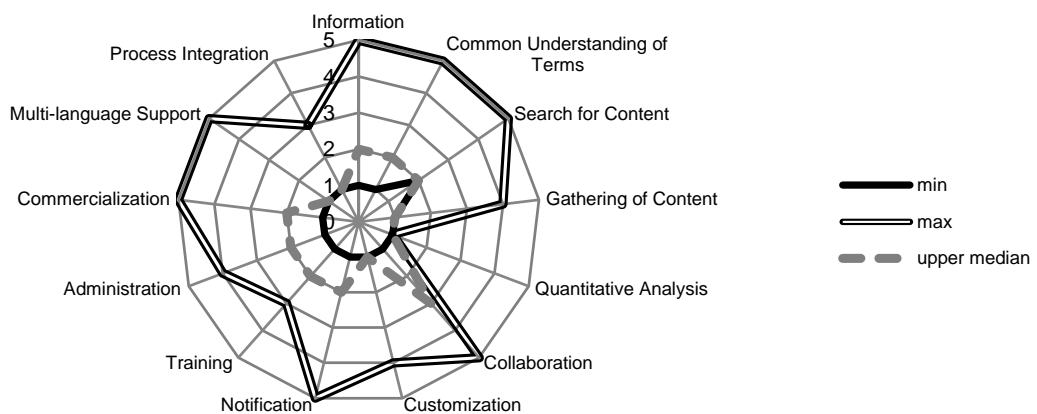


Figure 2: Cover Range of the Maturity Model

First, the minimum maturity level in the Search for Content dimension is two. A detailed analysis shows, that each of the 287 research portals supported content search in some way, at least through an alphabetical list (maturity level of two). This way, the first maturity level (“no support for content search”) does not occur in the data. It has to be discussed, whether it would be feasible to shift the assignments of maturity levels.

Second, the dimension of Quantitative Analysis seems to pose a problem. In our sample, none of the portals scored higher than maturity level one. No portal provided static or dynamic tables-based or graphical analyses. Although the authors know at least ten research portals providing these functionalities, the evaluation sample shows that they might be too rare to provide a feasible variability in the Quantitative Analysis dimension. It has to be discussed whether an upward assignment shift combined with a further differentiation in lower levels is necessary. Similar but not such serious problems seem to affect the dimensions of Process Integration, Customization, Training, and Gathering of Content. Here, a thorough in-depth analysis and discussion seem advisable as well.

Third, the central tendency (measured here with the upper median due to the ordinal scale of maturity levels) seems to oscillate around level two making the distribution of maturity levels left-skewed. This might, in turn, indicate that our maturity model is too demanding due to being relatively forward-

looking. If further evaluations confirm this assumption, it has to be discussed whether this future-orientation is a desirable property of our maturity models. In particular, it might be interesting to analyze, if and how the central tendency shifts in time along with naturally advancing research portals maturity.

Further, we analyzed the distribution of the five maturity levels for each particular research portals. In Table 6, we present the data for two exemplary chosen research portals. In the first case of the Concrete Pavement Road Map, the achieved maturity levels in different dimension provide a homogenous picture. Only the levels one and two occur. In the second case of the European Research Commission, however, the achieved maturity levels are very heterogeneous. Moreover, there exists a gap at level three. Although one would be able to propose a single maturity level for this research portal (e.g., measured through the median or mode), such a result would be unrepresentative for most dimensions and would not characterize the single portal well.

The second row is a specially chosen example of lacking level consistency, but such gaps or very heterogeneous distributions are generally undesirable. In our sample setting, this does not seem to be a serious problem, as gaps occur only in 15 % of the research portals and the outliers occur mostly only once in one dimension. However, in future changes to the maturity model it seems advisable to observe these distributions to avoid unrepresentative central tendency measures.

Research Portal	Portal Domain	Portal Operator Type	# of Occurrences of Maturity Level				
			1	2	3	4	5
Concrete Pavement Road Map	Environment	Private Research Organisation	7	6	0	0	0
European Research Commission	None	Public Research Organisation	5	5	0	2	1

Table 6: Analyzing Consistence of Maturity Levels for Two Exemplary Research Portals

Finally, we aimed at conducting an explorative analysis of the impact of two factors on the achieved maturity levels in particular dimensions. In Figure 3, we present a radar chart depicting achieved maturity levels with regard to the portal domain. We show the result for the domains of medical science, environment, and the case of no single domain dominating. This and the following diagram show central tendencies measured with the upper median. Our aim is to prove whether our maturity model allows for feasible interpretations in the context of our evaluation sample.

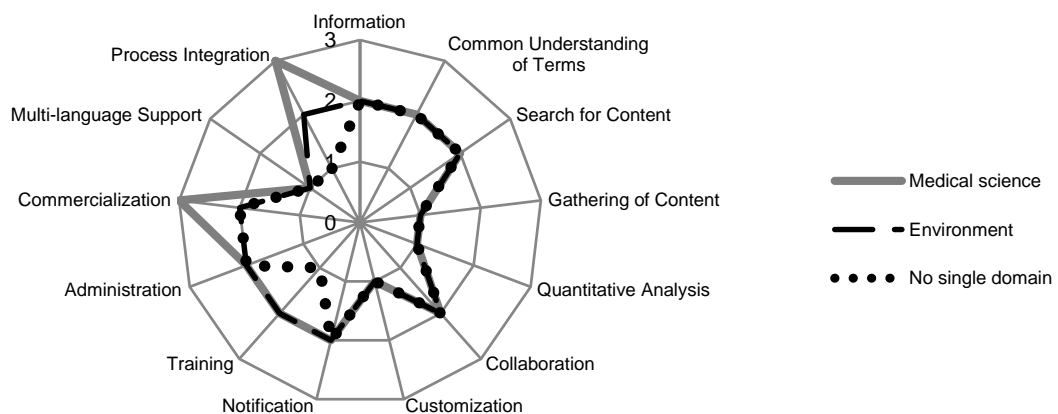


Figure 3: Dimension Maturity Levels with regard to Portal Domain

In the sample, research portals devoted to the domain of medical sciences achieve the highest maturity level of three in the dimensions of Process Integration and Commercialization. As research conducted in this domain is generally very resource-consuming, the tradition of supporting communities with research portals is well-established. This results in relative high maturity levels in Commercialization and Process Integration (since many portals exist already and need to be integrated). On the other

hand, research portals not devoted to a single domain but restricted to a defined user community provide less training opportunities and process integration. The former might result from lacking training needs due to community-own learning abilities. The relative low maturity level in the Process Integration domain can, on the other hand, result from the mostly individual and self-contained character of closed communities, which might make the need for inter-portal exchange dispensable.

In Figure 4, on the other hand, we present the impact of the portal operator type on the maturity level in particular dimensions – again using a radar chart. Here, the dimension of Notification contains the most level variability. A possible interpretation is that universities generally do not aim at informing their own members about news due to the mostly external orientation of their research portals. The generally high maturity level achieved by scientific journal-based research portals might result from the high professional approach followed by publishers, on the one hand, and the good knowledge of research communities, on the other hand. In our opinion, the maturity model already allows for feasible interpretation. However, shown deficiencies need to be thoroughly discussed in further development iterations and provided interpretations have to be proved on stability.

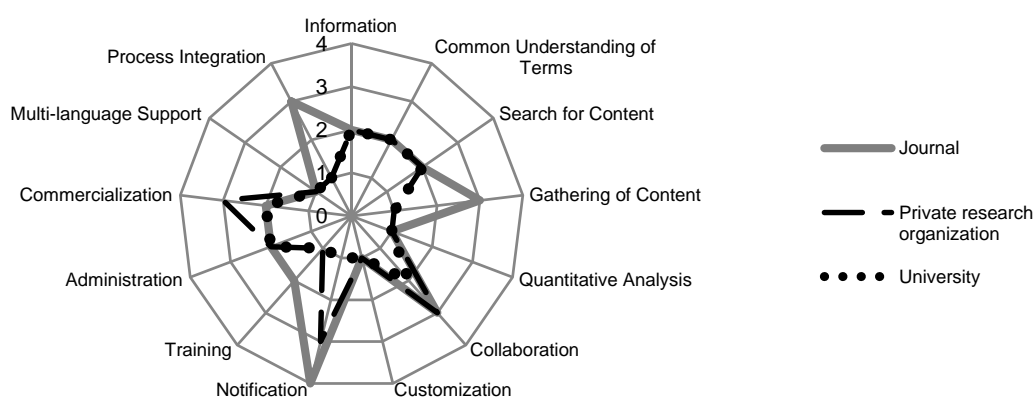


Figure 4: Dimension Maturity Levels with Regard to Portal Operator Type

5 OUTLOOK

Concerning the procedure model presented in Section 2, the present stage of development of the maturity model can be positioned at the end of the second iteration step, requiring at least a second re-evaluation. The main goal of further research is the stabilization of the reference model and the dissemination into practice. For this, it has to be analyzed whether 1) the repositioning of functionalities into different maturity levels and 2) a higher distinction of functionalities lead to better results. Finally, we want to extend the amount of portals to be analyzed to a census and substantiate propositions concerning the effect of for example *provider type* or *portal type* on the maturity of the model with statistical methods.

Once this has happened, the maturity model should enable users and portal administrators to conduct a self-assessment and identify improvement potentials for their portal. Furthermore, they should be able to benchmark their portal in comparison to results of other portals originating from the same class of provider or content type. The improvement of a portal's performance may lead to a better propagation of the research results presented, thus reaching a larger audience.

Furthermore, research sponsors expecting the dissemination of research solutions may use the maturity model to communicate their expectations about their respective extent. Research institutes, on the other hand, may benefit from additional contacts in the research community allowing for more interdisciplinarity. Additionally, the findings extruded from assessed research portals may support research in the field of sociology of scientific knowledge.

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