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Facilitating University–Industry Interaction by Visually Showcasing Researcher Profiles via Metadata

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Abstract:
University–industry interaction (UII) has grown significantly over the past two decades. Yet, contacting universities to establish collaboration continues to be perceived as challenging by the industry. This paper studies the challenges associated with UII for analysing how metadata, taxonomies and visualizations in research information management systems (RIMS) may support UII for large enterprises. The first step was a systematic literature review conducted to understand the challenges associated with UII. The second step was interviews with R&D managers from three large enterprises to extend our knowledge about this industry group. The results showed that the primary channel for establishing UII was through personal connections. The informants saw the RIMS as an important tool for browsing research literature and exploring research groups to gain insights into research topics and individual researchers. In terms of metadata, the findings showed that multi-disciplinarity and high-level granularity were important aspects. Furthermore, the visualisation of relationships and description of international collaborations was perceived a useful indicator of researchers' overall quality and impact. Similarly, metadata describing job titles, departments, and citations was central for judging the credibility of experts. An interesting finding was that enterprise managers found it difficult to develop personal relationships with relevant academic experts. Future studies may benefit from interviews with HR management professionals exploring how to support recruitment by using metadata and taxonomies.

1.0 Introduction

This study investigates the roles of taxonomy and metadata in showcasing researchers' qualifications by using research information management systems (RIMS) as a part of university–industry interaction (UII). In addition, we analyse how RIMS can be developed to visually showcase researcher expertise and explore how researcher profile data can be supported with taxonomies and metadata to better facilitate UII. Generally, UII is defined as the "interactions between all parts of higher-educational systems and the industrializing economy" (Ankrah et al. 2012, 50). UII has greatly increased over past two decades owing to an increase in federal funding for research and development (Azeroual, Saake, and Wastl 2018). RIMS are considered key tools for UII, and to design and manage RIMS, it important to not only update descriptions of experts' knowledge, skills, and impacts on an ongoing basis but also to provide high-quality data to ensure that RIMS can be used to support various user groups (Ebert et al. 2015). Data visualization is 'speeding up' the cognitive processes of filtering information; therefore, it plays an important role in the sciences as a method for generating insights (Fekete et al. 2012).

A growing number of studies have addressed the challenges associated with UII (Penfield et al. 2014). Recent scientific studies have outlined the diverse challenges facing UII, for example, finding partners for collaboration and contacting universities (Freitas, Geuna, and Rossi 2013). Another core problem is representing the specific knowledge and expertise in researcher profiles (Ehrlich 2003). It has been suggested that the needs and perspectives of large enterprises deserve special attention because such enterprises play a critical role in the world economy as innovators (Ebert et al. 2015). The gap between universities and the industry and the lack of knowledge in academia about large enterprises led us to formulate the following research questions:

RQ1: *What challenges do large enterprises face in terms of UII?*

RQ2: *How can we design metadata schemes and taxonomies so that they can provide researcher profile data that fulfil the needs of large enterprises?*

RQ3: *How can we graphically present researchers' profile data to enterprises to facilitate UII?*

2.0 Research methods

This study consists of two sub-studies: a literature review of the challenges associated with UII as they appear in previous studies and an interview study that extends and specifies the challenges faced by large enterprises and their viewpoints on metadata, taxonomy and visualization. RQ 1 is answered using the data obtained in the two studies. RQs 2 and 3 are answered using the data obtained in the two studies and the theoretical literature on information architecture (Morville, Rosenfeld, and Arango 2015) and visualization (Steele and Iliinsky 2010).

3.0 Literature review

This sub-study was carried out as a systematic literature review (LR), and the methodological process employed for this LR was inspired by Ridley (2012). The LR was performed with the following aims: 1) provide an overview of UII characteristics; 2) understand the motives of UII; 3) discover the challenges related to UII from the industry's perspective; 4) learn about the channels used to establish UII; and 5) understand how information should be presented to the industry. Titles that included terms such as UII, university–industry collaboration, and challenges or barriers to UII or university–industry collaboration were selected for inclusion in the literature review. Publications that included empirical data were prioritized because personal experiences are important in phenomenological studies (Lester 1999). In total, 27 publications were selected. A few of these publications were eliminated because they studied UII primarily from a university perspective or because they were considered unreliable sources or were not peer-reviewed. Only 20 publications were reviewed in detail, and among them, only 8 were included in the actual analysis. During the reading process, the texts were colour-coded to help address the synthesis among the selected articles (Ridley 2012). The reviewed literature covered UII from the perspectives of large and small and medium-sized enterprises.

4.0 Interview study

Three large-sized engineering enterprises based in Northern Jutland were selected for the case study. These three enterprises fit the definition of large enterprises, that is, enterprises with more than 250 employees (Løkkegaard 2018). The interview study consisted of three interviews with research managers, one from each of the enterprises. The field of engineering was selected because it is one of the leading areas for UII (Murashova and Loginova 2017). The target sample was identified using a combination of convenience and purposive sampling methods (Bryman 2016). The main selection criteria were as follows: Informants should have professional functions related to universities or research activities, and UII should be relevant to the informants' companies. Informants 1 and 2 had dual positions: they worked as research managers with their respective companies and as part-time industry professors with Aalborg University. Informant 2 was with Aalborg University as a supervisor for master's students. For details, see Figure 1.

	Industry name and type	Educational background	Work title/ functionalities	Relationship with University	Gender	Enterprise size
Informant 1	Mechanical engineering, water system solution development	M.Sc., Control Engineering and Automation Ph.D. in Control Engineering	Chief Engineer/Chief Specialist, working with control and supervision systems both at Grundfos and Aalborg University	Industry Professor, part-time Professor at Department of Electronic Systems, The Technical Faculty of IT & Design, Automation & Control	Male	<19,000 employees globally
Informant 2	Robotic optimization development for industry	M.Sc., Mathematics & Computer Science	Product Manager: business development, concept development and product management	No university-related position	Male	<370 employees in Denmark, Sweden and Norway
Informant 3	Manufacturer of electronics and audio products, television sets and telephones	M.Sc. and PhD in Acoustics	Director Research, responsible for research activities and managing research groups	Industry Professor, part-time professor at The Technical Faculty of IT and Design, Electronic Systems, Signals & Information processing	Male	<1,028 employees

Figure 1. Information about selected sample and industry.

The RIMS and the related metadata scheme and taxonomy used by Aalborg University were presented to the participants as an exemplary RIMS system during the interviews. This RIMS was selected because it supports the visualization of academic expertise, networking and collaboration. The taxonomy and related metadata were discussed and evaluated together with the visual presentation of researcher profile data. Several graphics were discussed during the interviews, for instance, visualizations generated using a fingerprint algorithm that captured subject terms from uploaded abstracts and network visualizations displaying the relationships between researchers and academic departments, as shown in Figures 2 and 3 (Elsevier 2016).

Figure 2. Network visualization of researchers with other individuals and research units.

The interviews were exploratory and open ended, and the informants were asked questions about the following themes: 1) understanding the contexts of the informants and their perceptions of UII and RIMS; 2) evaluating the categories and metadata in the RIMS; 3) evaluating graphic visualizations in the RIMS; and 4) gathering insights as to whether the RIMS can facilitate UII. The interviews were started by asking the informants to sign a consent form, and they were conducted in natural settings with the informants sitting in their offices. The interviews with informants 1 and 2 were conducted in person at their offices, while the interview with informant 3 was conducted online, wherein the informant sat in his office and the researchers in the university. The researchers shared their screen with the informant during the interview to allow the informant to explore the RIMS. The interviews were recorded and transcribed, leading to more than 160 min of interview video in total.

A thematic meaning condensation process was used to analyse the transcriptions, and commonalities, relationships and differences across the data were identified (Gibson and Brown 2009). The exploratory process of meaning condensation was used because it provided the researchers with reflective and detailed steps to conduct data analysis (Malterud 2012). A 'meaning unit' is defined as a fragment of text containing some information relevant to the research question (Malterud 2012). Inductive reasoning was adopted to conduct the analysis. NVivo computer software was used to perform the analysis (NVivo 2020).

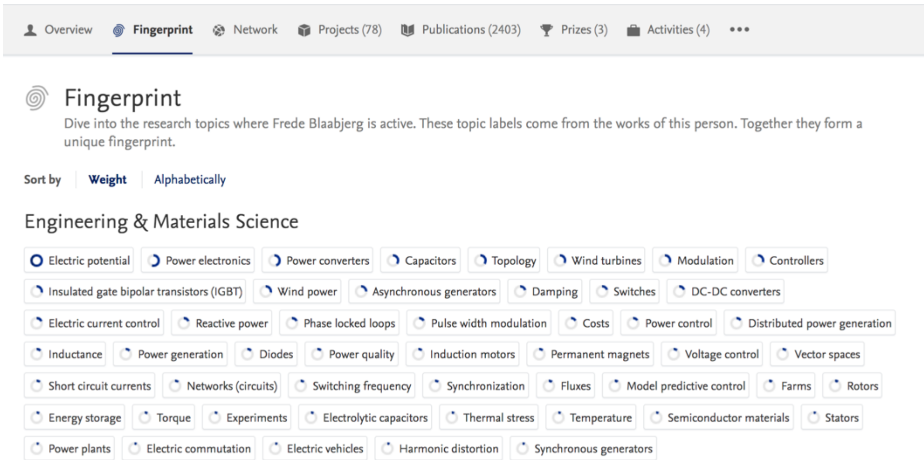

Figure 3. Fingerprint concepts of individual researcher profiles.

5.0 UII characteristics and challenges

The LR findings confirmed a lack of studies focused on investigating UII challenges, for example, challenges related to the identification of experts by using the RIMS. The majority of the studies focused on industry perceptions of the university (Vick and Robertson 2017). The review showed that the primary motives for UII were ‘rising costs’ and ‘societal constraints’. On a personal level, academics were self-oriented to engage in UII for creating career opportunities within their organizations (Vick and Robertson 2017). Surveys conducted in 9 academic departments across 115 universities suggested that researchers are careful in establishing UII because it restricts their academic freedom. Moreover, the surveys indicated an underlying tension for research funding that weighed against the need for academic freedom (Ankrah et al. 2012). The need to find and hire talented students was a motivating factor for the industry to establish UII (Ankrah and AL-Tabbaa 2015). Additionally, the desire to attain ‘competitive advantages’, ‘stability’ and ‘legitimacy’ were further motives for establishing UII (Ankrah et al. 2012).

Large enterprises have a large absorptive capacity for using scientific knowledge and better capabilities in terms of searching and identifying knowledge providers (Ankrah et al. 2012). According to a study, the main challenges associated with establishing effective UII were organizational differences between universities and the industry (different aims, levels of formality, risk perceptions and values) (Collier, Gray, and Ahn 2011). Similarly, enterprises were found to perceive universities as ‘a different working environment’ (Ankrah and AL-Tabbaa 2015). Quality issues were identified as a challenge, and academics were perceived to be too theoretical and not very practical, whereas the industry’s focus is considerably more practical with a centred interest on critical issues (Ankrah et al. 2012). Moreover, companies find it difficult to approach and make contact with universities (Ankrah et al. 2012). Enterprise managers find it difficult to ‘identify skills, their firms needed and then to develop personal relationship with academic experts’ (Ankrah and AL-Tabbaa 2015).

Our analysis of the interview study revealed similarities between the findings of the LR and those of the interviews, such as enterprise size and its effect on absorptive capacity (Freitas, Geuna, and Rossi 2012). However, the interview findings provided more insights and unexpected findings. Informant 1 described how they perceive their company as a 'look-alike-university' and are familiar with scientific knowledge. Moreover, the interview findings suggested that within enterprise 3, in-house research groups are formed, and these groups tend to solve problems internally. This finding was unexpected because according to the LR, large enterprises tend to use collaborative research programs rather than in-house research programs to reduce costs (Ankrah and AL-Tabbaa 2015).

Another finding was that for large enterprises, it is important 'to collaborate with people that they know' (Informant 1). Similarities were found with regard to the LR findings because in some cases, it is not the expertise or the qualities of an expert that matter but rather the 'personal traits of the academic expert' (Collier, Gray, and Ahn 2011). Another similarity between the findings of the LR and the interview study was that enterprises use 'personal contacts' as a channel for establishing UII (Ankrah and AL-Tabbaa 2015). The LR suggested that the challenges faced in establishing effective UII were the 'difficulty to make contact with the university' and identification of the right partners' (Freitas, Geuna, and Rossi 2012). However, a surprising discovery that was disproven by the interview study was that finding an expert for collaboration and contacting a university were not perceived as problems by the informants. One explanation may be that the three informants maintained close collaborations with Aalborg University (AAU) through internship programs, as well as the close connections between the university and surrounding enterprises owing to the AAU tradition of problem-based learning, which encourages students to collaborate with enterprises in their project work to work on real-life cases (Aalborg University 2020).

6.0 Metadata, taxonomy and graphics in RIMS

The LR study revealed that the information presented to an enterprise should be 'easy to use', 'practical', 'visually attractive', 'short and specific' and 'quickly decoded' (Løkkegaard 2018). Visual aspects such as an expert 'profile picture' are important, and the RIMS should be supported with taxonomy to ensure that it represents user needs (Ehrlich 2003). Moreover, it was suggested in a study that granularity provides one with the ability to rank experts by using narrower criteria and showcasing multiple relationships among experts, co-authorship, citation links and project groups (Yimam-Seid and Kobsa 2003). Enhancing the RIMS with ontology-based presentations of expertise, such as subset-superset relationships and multidisciplinary and interdisciplinary expertise, considerably increases the probability of selecting the right expert (Yimam-Seid and Kobsa 2003). Similar findings from the LR were that 'expertise' and 'subject categories' should be supported by a highly granular taxonomy and that metadata should contain 'credentials', 'accessibility' and 'demographics' of the profiled researchers (Ehrlich 2003). Moreover, it must be possible for one to assess an expert's credibility by reviewing their 'published papers and awards', 'grants and patents' and 'professional affiliations' (Ehrlich 2003). During the interviews, it was found that when looking for academic experts, the informants started their search in the 'publications' category.

Informants 1 and 3 explained that they looked for topically relevant publications to identify universities and research groups that were publishing within the field of interest and could, thus, be considered relevant for their enterprise. They searched by 'concepts' and 'topics'. The specific topics that represented their field and domain vocabulary were important and relevant to the informants. This was reportedly the first step towards finding relevant experts.

Descriptive metadata about publications, such as title, author and abstract, were found to be important. The abstract helped the informants judge whether a subject was interesting and whether a publication was theoretical or application-oriented. The second step was to quickly identify the 'leaders' of the publications or members of the 'research group' because these data provided information about the overall quality of the research/researchers. The three informants found that citation indexes presenting productivity and metrics provided useful descriptions that helped them identify the level of activity of a researcher and whether a researcher was a professor or a PhD student. Moreover, such indexes 'help identify the key supervisors or leaders of a research group' (Informant 1). Similarly, the h-index helped 'identify the key scientific persons in this topic area' (Informant 3). Commonly, PhD students would have a lower index. This means that citation indexes and the h-index were considered useful sources of metadata that helped the informants assess an individual's level of expertise. The informants stressed that metadata about research activity on specific topics across departments and international collaborations should be included in the RIMS. The findings of Løkkegaard (2018) supported the interview findings that subject information about researchers' scientific knowledge is important for enterprises. She added that scientific knowledge should be presented such that it is clear how the knowledge can be used and applied in practice. Informant 2 stated that graphical expertise exposure was important and useful because 'it helps the memory' and assists with 'interpretation of information'. Profile pictures were considered important because they 'give an idea of what a person is'. According to Informant 1, visual presentations 'catch attention', thus confirming that visual exposure is important and supports cognition. Visual information is considerably easier to perceive than textual information (Shneiderman 1996). Likewise, the availability of researcher profile pictures in expert-finder systems was found to be important (Yimam-Seid and Kobsa 2003a).

According to the LR, an unusual finding of both the LR and the interviews was that enterprise managers found it difficult to 'identify skills their firms needed and then to develop personal relationship with academic experts' (Ankrah and AL-Tabbaa 2015). Informant 1 explained how network visualization could be useful from the perspective of staff management because it would help one plan which are the 'places where we want to work, which topics to work on and who we want collaborate with'.

To sum up, in most cases, the interview participants found useful the metadata and taxonomy used in the Aalborg University Pure Portal. The 'publications' category was relevant from the viewpoint of searching for experts, and the 'subject' category allowed the informants to search the Pure Portal for information by automatically generating 'concepts' and 'topics' as categories. Metadata describing the 'title', 'department' and 'individual and research unit collaborations' were deemed useful. Furthermore, the 'citation index' and 'h-index' were found to provide useful information about the credibility of an expert. However, some taxonomy terms and metadata types were missing. The interview participants missed metadata describing the ‘leader’ of a research group, which would be useful for identifying the leader of a publication. Metadata related to and describing ‘international collaborators’ and ‘departmental collaborators’ were considered useful information as well. Likewise, it was found that metadata on external individuals who have collaborated with an expert would be useful for network visualization. The findings further suggest that for graphic visualizations to facilitate UII, they must be informative and communicate the information that is relevant to a user. When designing a visualization, it is important to prioritize information over a superfluous design that can confuse the user. To ensure that the visuals remain relevant, the designers should achieve a balance between novelty and efficiency; in other words, redundancy should be minimised, so that the intended meaning is not lost in pursuit of a highly unique design. Likewise, visualizations should present the use context and information in an effective manner to support UII. The study found that graphic visualizations that can be explored (provide relationships to different datasets) are more relevant than those that do not facilitate exploration. Similarly, visualizations that employ graphic elements for enhancing important information (by using colours or bold characters) are perceived as useful and more efficient. Minimizing visual clusters by reducing redundant graphical elements, such as lines or numbers, may help make a visualization more aesthetically attractive.

For graphic visualizations to be informative, they must be supported by useful metadata that expresses a clear, unambiguous meaning and showcase metrics that can answer users’ questions. To support visualizations, metadata terms must be specific, clearly describe the intended message and provide metacommunication to support the context of use. The taxonomy vocabulary should avoid ambiguous terms and should maintain specificity and domain-orientation. Simultaneously, the taxonomy must provide multidisciplinarity, in addition to showing and relating perspectives and vocabulary from a set of relevant domains.

8.0 Conclusion

This study explored metadata, taxonomy categories and graphic visualizations as means to support descriptions of researcher expertise in RIMS. This showcase aims to solve the challenges associated with UII, and consequently, improve the interaction between universities and the industry. Moreover, the study explored UII from the perspective of large enterprises. The LR findings suggested that when searching for academic knowledge and researchers, industry professionals prefer graphic visuals instead of textual information because visuals catch their attention and are easy to understand. Moreover, enterprises find it challenging to establish collaborations with universities. Therefore, the study aimed to understand how to better present researcher expertise with metadata and a granular taxonomy to resolve the challenges associated of finding the right experts for establishing UII. Taxonomy and metadata provide context, consistency and information regarding visualizations and help enterprises to determine the level of expertise and cross-departmental collaboration of an individual. A prototype RIMS was used as a typical identification case. The essential finding of this study is that establishing UII was not perceived as a problem by the informants, which contradicts the LR findings. This contradiction was ascribed to the informants’ close personal connections with the university. Personal contacts were found to be the most efficient channels for interacting with researchers, as opposed to RIMS. Moreover, visualizations were found to be important and useful for enterprises because they provide a 'quick interpretation of information'. Metadata should support the descriptions of visuals and provide meta-communication regarding the context of use and how the visuals were generated. Multidisciplinary descriptions are important for the industry, and therefore, taxonomy should include high-level granularity and domain-specific terminology to support information.

In sum, the findings provided an understanding of UII from the perspective of large enterprises in relation to graphic exposure, taxonomies and metadata in RIMS. However, it is important to stress that improving the taxonomy and metadata would not necessarily change the ways in which industry actors establish collaborations with academic experts, because collaborating with people who are personal connections is still the preferred route for establishing interactions. Future studies should explore industry professionals in management positions to explore how metadata can support recruitment and business development.

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