

Spring 6-10-2017

ALIGNING IS CURRICULUM WITH INDUSTRY SKILL EXPECTATIONS: A TEXT MINING APPROACH

Patrick Föll

University of Wuerzburg, patrick.foell@uni-wuerzburg.de

Frédéric Thiesse

University of Wuerzburg, frederic.thiesse@uni-wuerzburg.de

Follow this and additional works at: http://aisel.aisnet.org/ecis2017_rip

Recommended Citation

Föll, Patrick and Thiesse, Frédéric, (2017). "ALIGNING IS CURRICULUM WITH INDUSTRY SKILL EXPECTATIONS: A TEXT MINING APPROACH". In Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 2949-2959). ISBN 978-0-9915567-0-0 Research-in-Progress Papers.
http://aisel.aisnet.org/ecis2017_rip/44

This material is brought to you by the ECIS 2017 Proceedings at AIS Electronic Library (AISeL). It has been accepted for inclusion in Research-in-Progress Papers by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

ALIGNING IS CURRICULUM WITH INDUSTRY SKILL EXPECTATIONS: A TEXT MINING APPROACH

Research in Progress

Föll, Patrick, University of Wuerzburg, Wuerzburg, Germany,
patrick.foell@uni-wuerzburg.de

Thiesse, Frédéric, University of Wuerzburg, Wuerzburg, Germany,
frederic.thiesse@uni-wuerzburg.de

Abstract

Digitalization offers both great opportunities as well as new challenges and uncertainties. In particular, students in their role as future employees will have to cope with the new digital environments, which makes lifelong learning and up-to-date skills even more important than they already are. Key players in this long-term development are the universities as providers of the necessary skills and knowledge. By now, it is clear that digitalization will have a broad impact on the future conditions of universities. But are they already prepared for it? Against this backdrop, we present an approach to combine universities' offerings with the required industry job skills to identify potential curricular gaps at course level that arise through ongoing digitalization and, as a consequence, changing skill requests for employees. We identify an appropriate set of methods for our project including text mining methods, an expert survey and an interview phase for evaluation. We illustrate our approach using a large data set of German IS curricular module descriptions and offers for IS job starters.

Keywords: IS education, IS job skill requirements, Digitalization, Text mining.

1 Introduction

Digitalization, that is the use of digital technology to generate new revenue, more information or simply more convenience, is spreading in every aspect of education, work, and life in general (Stoltermann and Croon Fors, 2004). According to the European Commission (2016) “new digital trends such as cloud computing, mobile web services, smart grids, and social media, are radically changing the business landscape, reshaping the nature of work, the boundaries of enterprises and the responsibilities of business leaders. [...] Businesses that fail to get digitally connected will become excluded from the global market.” Digitalization offers enterprises both great opportunities as well as new challenges and uncertainties. Students in particular, as future employees, will have to cope with the new digital environments, which makes lifelong learning and up-to-date skills even more important than they already are. Universities are key players in this long-term development, providing our society with the necessary skills and knowledge. By now, it is clear that digitalization will have a broad impact on the future conditions of universities (and enterprises). But are they already prepared for it?

A thorough review of the literature on IS curriculum reveals that prior research has not yet focused on this question, as a large amount of the reviewed work, on the one hand, was carried out at a point at which the current possibilities and implications of digitalization could not have been foreseen nor expected; or, on the other hand, mentioned digitalization as an important driver of change (Debortoli et al., 2014), but no answer to its challenges was given. As IS curricula are said to slowly adapt to

changes in the “real world” (Granger et al., 2007; Hirschheim and Klein, 2003; McGann et al., 2007), we address the challenges digitalization is bringing to universities and students as future employees by examining industry demands for workforce competencies on the one hand and universities offerings on the other hand. We try to combine both data sources using the European e-Competence framework for competencies as a base for comparison. Our aim is to identify white spaces in current curricula, and if so, to develop strategies to fill them at course level to support stakeholders in politics, academia and industry in preparing society for digital change.

To develop our approach, we apply and combine well-established methods and findings from the fields of university, labour market and IS research to the example of German IS programmes. For this purpose, we collected curricular data of 188 German IS university programmes from programme descriptions and module manuals. In total, the data set contains about 9,500 different module descriptions that we will examine using a topic modeling approach. In addition, we scraped three German job platforms for IS related job starter offers. As students normally do not possess substantial job experience, they are most likely about to apply for this kind of jobs. We collected about 10,900 job offers from the platforms, which will also be processed in a topic modeling step. To compare across the data sets, we plan to use the European e-Competence framework as connection between them. As suggested by Debortoli et al. (2014), Todd et al. (1995) or Litecky et al. (2010), we expect the results to provide insights into labour market requests for competencies as well as into the competency offerings of each considered study programme and its accuracy of fit for different IS job profiles. Furthermore, we expect the results to indicate where there may be white spaces in the offerings of universities as there may be competencies demanded by labour market, which are not covered in curricular modules. We plan to evaluate our approach through a follow-up expert survey, after which we perform adjustments, if necessary. By adding a final interview phase we will try to identify the underlying causalities and give recommendations for the direction of future curriculum and course development.

2 Related Work

The research objective of aligning IS curriculum with industry skill expectations shows overlappings with three different research fields: (i) university and (ii) labour-market research as well as (iii) IS education research. The related work in these fields is divided along two axes as depicted in Figure 1, where a classification of the different approaches is provided. On the one hand, there are studies pertaining to the guidelines for curriculum design of IS courses (Davis et al., 1997; Gorgone et al., 2006; Topi et al., 2010), and the evaluation of how they are used in university reality (Yang, 2012; Dwyer and Knapp, 2004; Williams and Pomykalski, 2006; Lifer et al., 2009). To generate the guidelines, the studies mostly applied traditional data gathering methods, such as (expert) interviews or questionnaires, to discover the curricular needs of IS. To evaluate them and their uses, the preferred methods are data-driven approaches via content analysis (Stefanidis et al., 2013; White, 2005). Stefanidis et al. (2013), for instance, carried out a study on the career tracks of the IS 2010 model curriculum by Topi et al. (2010) in UK universities. On the other hand, there are studies on business skill expectations in IS-related job categories. They cover the skill requirements in a field of work characterized by innovation and technological change, which are often sources of competitive advantages (Gallivan et al., 2004; Hickson, 2000; Nelson et al., 2007). A majority of these studies is empirical; they gather their information via traditional questionnaires and interviews or through data collection in printed or online job advertisements. Stefanidis (2014), Wilkerson (2012), Chia-An and Shih (2005) and Litecky et al. (2004) provide comprehensive views of the huge volume of literature in this field. We therefore only examine the different approaches in brief. Studies trying to discover the required skills through standardized questionnaires are carried out quite often. One of the first was conducted by Benbasat et al. (1980), which influenced others like Igarria et al. (1991) or Leitheiser (1992) to use almost similar approaches. Questionnaire respondents range from employers (Lee and Mirchandani, 2010; Noll and Wilkins, 2002; Downey et al., 2008), to employees (Davis, 2003) or students (Fang et al., 2004; Chrysler and van Auken, 2002), whereas a majority focused on employers.

Only a few inquiries use interviews to identify work skills. As interview partners, the existing work focuses on managers or employers (Cheney et al., 1989; Ehie, 2002; Nettleton et al., 2008; Simon et al., 2007); only some focused on other groups, e.g. Chang et al. (2010) interviewed students and Benamati et al. (2010) academics.

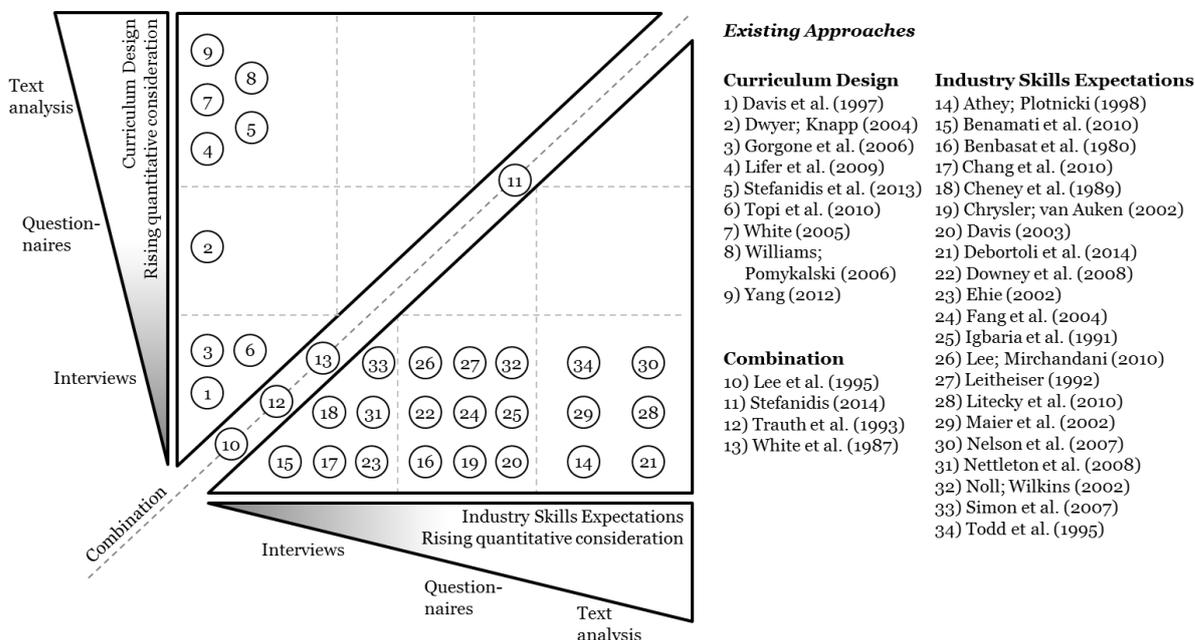


Figure 1. Existing approaches in reviewed literature

Data-driven approaches include the analysis of newspaper job advertisements like the one carried out by Todd et al. (1995), which influenced upcoming studies in the field like Athey and Plotnicki (1998) or Maier et al. (2002). Today, this approach is mostly replaced by the new possibilities, which have occurred with the rise of the internet with online job platforms and their analysis via modern text mining methods. Representative examples of this approach are Litecky et al. (2010), who used data mining to extract 250,000 IT job advertisements in the US, or Debortoli et al. (2014), who examined business intelligence and big data job advertisements. Of the reviewed literature regarding industry skill expectations, only few (e.g. Trauth et al., 1993) focussed on the specific skill expectations for IS job starters. Most studies had a general view on job offers and the requested skills. We think of this as a gap we want to address within our approach. Some studies try to combine the curriculum and job market directions to obtain the correlation between the skills supplied by universities and the skills demanded by industry (Litecky et al., 2004). Through this combination, they aim for a more suitable skill provision at university to better prepare students for job market expectations. They use mixed methods to achieve this goal, from interviews (White et al., 1987; Trauth et al., 1993) over questionnaires (Lee et al., 1995) to data-driven approaches (Stefanidis, 2014). Most of the reviewed work was carried out at a point at which the possibilities and consequences of the digitalization could not have been foreseen nor expected. However, by now it is clear that the digitalization has an extensive impact on the future conditions of universities and industry; e.g. in Debortoli et al. (2014), digitalization is identified as a key driver for change in both industry skill expectations and curriculum, which requires its involvement in further research.

3 Research Approach

To contribute to this research, we want to provide insights based on quantitative data, which will be evaluated by an expert survey. Located in Figure 1, our approach would be situated in the upper right quadrant. The main research question the project addresses is the following: “Are German IS curricula

prepared for the challenges that the digitalization of more and more industries faces them with, or are there curricular gaps that need to be filled at course level?” To answer this, we first have to respond to two other questions: (i) which competencies impart the German IS study programmes their students and (ii) which competencies request employers from students. For this purpose, we plan to use the approach illustrated in Figure 2. The selection and collection of curricula and job offers are already completed. We prepared a sample of the resulting data sets to conduct first topic modeling attempts with promising results. Therefore, we will proceed to the processing of the entire data. The different steps of the overall approach are presented in detail in the following sections.

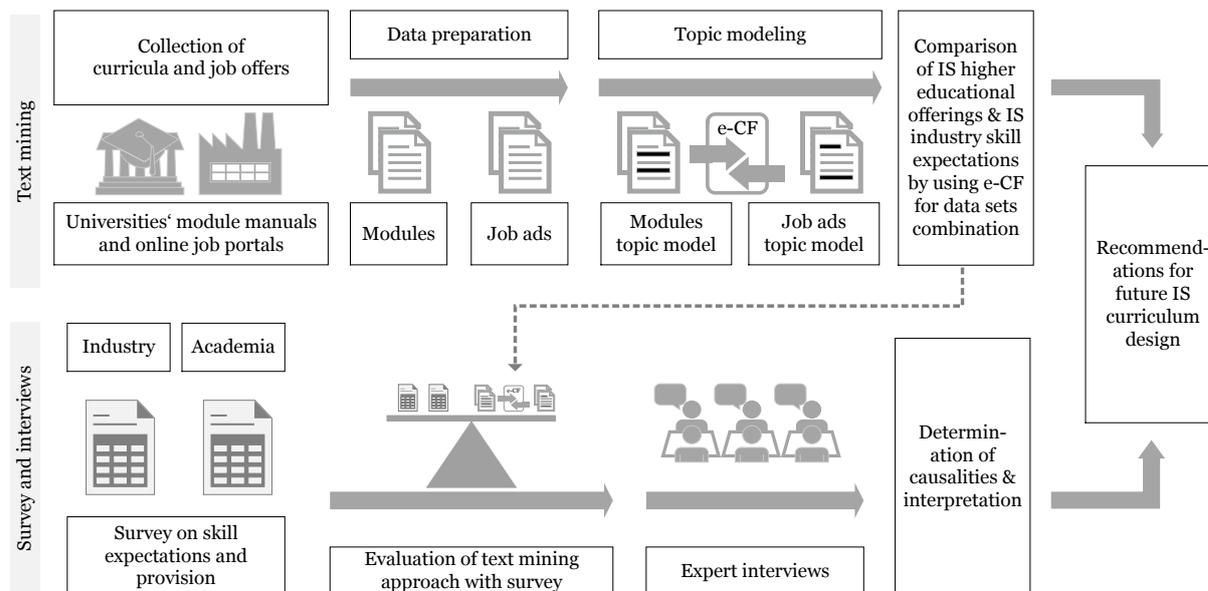


Figure 2. Schematic research approach overview

3.1 Collection of curricula and job offers

The data selection and collection includes two steps: the selection and collection of (i) German IS module manuals and of (ii) German online job advertisements for IS job starters.

With regard to (i), there are – according to the HRK (2016), the university’s umbrella organisation in Germany – 247 IS study programmes in Germany, bachelor and master, at universities and other institutions for higher education. Our requirements comprise IS study programmes with standardized module manuals, to be able to compare them to each other. This applies to 188 (or 76%) of the study programmes, as they are accredited and therefore ran through a standardized process, which includes specific requirements for the module manuals like a prescribed structure, detailed module descriptions, qualification aims, etc. Table 1 illustrates the distribution of the considered study programmes along the different types of degree, sponsorship, size and university types that exist in Germany. For the categorization of the university sizes, we use the definition given by Stifterverband (2013). Overall, we cover a broad variety of study programmes that should allow us to draw conclusions on the whole field of IS curricula in Germany. On average, each study programme contains about 50 modules, so that our corpus covers about 9,500 modules (i.e. documents). Even though they contain approximately the same type of information, they are not structured enough to be directly used for further processing. On the one hand, they are all formatted differently, which makes fully automated data extraction out of the PDFs into a structured database impossible. On the other hand, the different module descriptions partly contain data that would be harmful for topic modeling (e.g. requirements to study a specific module, which are irrelevant to the contents of the module). We therefore used a semi-automated process of extracting the contents of the module manuals and copying them rule-based into a structured form to exclude any misleading data.

University type	Universities (with right to award doctorates)		Universities of applied sciences – “Fachhochschulen” (without that right)
Amount	60		128
Type of degree	Bachelor / undergraduate degree		Master / graduate degree
Amount	129		59
Sponsorship	Private universities, state approved		Public universities
Amount	26		162
University size	Small ($\leq 5,000$ students)	Medium (5,001 – 15,000)	Large ($\geq 15,000$ students)
Amount	54	87	47

Table 1. Overview on gathered German IS study programmes and universities

Regarding (ii) the job advertisements data set, we gathered German IS related job starter offers from three big online platforms: one general platform (stepstone.de) and two platforms specialized on job starters (get-in-it.de and absolventa.de). The three platforms contain the largest identifiable offer for German IS job starter advertisements. We focus on job starter offers as those jobs are the ones graduates most likely apply for. The competencies needed for these jobs are the ones graduates should provide; including all kind of job offers (i.e. for experienced employees) would distort the results. To collect the data, we wrote a web scraper in R for each website and saved the contents in SQLite databases. As a result, we collected about 10,900 records (i.e. IS job starter advertisements). Table 2 shows the distribution of the job advertisements, which indicates that we cover all relevant categories, industries, and company sizes of the IS labour market in Germany.

Job categories (one job offer may have more than one category)	IT-Administration 1,762 entries	IT-Compliance 162 entries	IT-Consulting 3,215 entries	Databases 745 entries
	Hardware Development 421 entries	IT-Management 406 entries	Process Management 115 entries	Product Management 173 entries
	IT-Support 264 entries	Web-Development 1,918 entries	Research 212 entries	IT-Security 97 entries
	Project Management 799 entries	Quality Management 981 entries	Software Development 4,354 entries	System Engineering 541 entries
Industry of searching enterprises (each offer is assigned to one industry)	Accounting and Law 367 offers	Automotive and engineering 1,358 offers	Education and Research 149 offers	Transportation and Logistics 148 offers
	Aerospace 124 offers	Consulting 628 offers	Finance 400 offers	Trade 503 offers
	Temporary Employment 2,554 offers	Production and energy 242 offers	Pharma and chemical 63 offers	Marketing and Media 225 offers
	Food and Health 144 offers	Public Service 60 offers	ITC 3,725	Others 192
Size of enterprises (each offer is assigned to one size)	Micro (≤ 9 employees) 335 offers	Small (10-49 employees) 1,027 offers	Medium (50-499 employees) 4,009 offers	Large (≥ 500 employees) 5,500 offers

Table 2. Overview on gathered German IS related job starter offers

To prepare the table, we enriched our job offers data set with data about industries and company sizes from a linkedin.com crawler, that we developed for this purpose. Originally a network for social business contacts, LinkedIn also offers page visitors a directory for enterprises and information about them, for example, in which industry they are and how many employees they employ. In our crawler, we used this directory to automatically gather the required information. We joined the data sets via the company names of the job offers to create table 2. For the categorization of the company sizes we used the definition by IfM Bonn (2016), which reflects the German specific industry landscape for middle-sized companies. Through the structured HTML-format, the job offers are much easier to handle than the curricular data. They also contain irrelevant data elements (e.g. information about the enterprises themselves or what they offer to employees), but it is much easier to exclude these. Because job offers are usually organized in labeled subsections, the irrelevant elements can be recognized and ignored during scraping. The main effort here was to join the data sets from the three different platforms to one big data set as they do not all contain the same information or are formatted in different ways.

3.2 Generation of topics from module and job descriptions

As most of the data we gathered is unstructured, for the next step we will rely on the use of text mining methods to prepare and process the data. Owing to the fact that there are a lot of specific fields of application for text mining – as it intersects various disciplines with different aims – we used the framework by Miner (2012) to identify the appropriate methodology. The framework led us to the application area of concept extraction, the range of methods in this field is summarized under the term “topic modeling”. The basic idea behind topic modeling is that every document consists of latent topics, which are characterized by specific word allocations. All topic modeling methods try to attain the identification of topics by unsupervised learning. The first approach to attain the goal was the Latent Semantic Analysis (LSA) by Deerwester et al. (1990). It reduces the dimensions of a word-document matrix to identify the latent concepts in the documents. Hofmann (2001) extended the LSA with a probability distribution; his approach is, therefore, called Probabilistic Latent Semantic Analysis (pLSA). Its main enhancement is to add a variable to each co-occurrence of documents and words; each co-occurrence is associated with that variable. They will then be interpreted as latent concepts. Based on those methods, Blei et al. (2003) developed Latent Dirichlet Allocation (LDA) method. LDA is a Bayesian model in which each word in a document is assigned to one or more topics. It includes dirichlet priors for the topic-word distribution, which means a “distribution over distributions” for preventing over-fitting. The last main topic modeling approach is the correlated topic model (CTM). It can explicitly address correlations among the latent topics. It follows the same process as LDA, with the difference of using logistic normal distribution in case of dirichlet distribution (Lee et al., 2010). We use the LDA topic modeling method, as it seems appropriate for our proposed field of application. It is a generic model, which allows it to be used on the different types of documents we will consider, as they vary from university module descriptions to job advertisements (Lee et al., 2010; Alghamdi and Alfalqi, 2015). We do not need the method to consider the relationships between the topics so that the use of CTM – with its higher complexity and shortcomings in the topic word selection – does not seem to be necessary. We perform text mining for both data sets: once for the curricular data (i.e. the module descriptions) and once for the required industry job skills (i.e. the job descriptions).

3.3 Linking of curricular and job data with the e-Competence framework

We plan to combine both data sets using the European e-Competence framework (e-CF); a framework developed by a large group of European ICT and HR experts to create a common understanding of competencies, skills and proficiency levels across Europe (European Committee for Standardization 2014). It is published as a European standard (EN 16234-1) and provides a set of 40 predefined competencies like application development or project management across five dimensions (plan, build, run, enable, manage). Each competency comes along with a detailed description. We intend to enable the combination by taking the descriptions of each competency out of the e-CF and use them as a doc-

ument for both topic models. With the result (the occurrence of each of the topics out of both topic models in the document) we will be able to combine the data sets across those competencies. Through the combination of both data sets using the e-CF, we will be able to answer our main research question, whether German IS curricula are prepared for the challenges of digitalization. It shall be possible to identify potentially existing white spaces on the education supply side to fulfil the requests of the labour market demand side.

3.4 Evaluation and validation with stakeholder survey and interviews

To evaluate the results and determine the underlying causalities, we will carry out a survey and interviews with experts from academia and industry. We plan to involve the stakeholders, as they have an inherent interest in the findings (Petrova and Claxton, 2005). As experts from academia, we consider professors of the examined study programmes. As experts from industry, we choose managers and recruiters from enterprises out of our job advertisements data set. In a first step, both groups will receive a questionnaire designed after the research done by Trauth et al. (1993) and Noll and Wilkins (2002). The skills in the questionnaire will be aligned with the identified topics, with the possibility to add additional competencies. Industry experts are asked to indicate the importance of the different IS skills for their enterprises. Academia experts are also asked to indicate the importance of the skills for IS professionals, and in addition to provide information about the extent to which the skills are emphasized in their study programme. This setup offers two advantages: first, through the possibility to add additional competencies, we are able to evaluate the fitting of our topic models. If there are many competencies added, we have to adjust the model-specific parameters to reach better coverage. Second, we can use the survey results as benchmark for the findings from our overall approach by comparing the importance of the competencies on the one side to the topic frequency on the other side. If both outcomes point in the same direction, we consider our concept as a valid approach to identify skill expectations and provision. In the end the overall results are presented to the stakeholders in order to determine and interpret the causalities of our findings toward the alignment of German IS curriculum with workforce demands for competencies. Following Bogner et al. (2014), we conduct this step in the form of theory-generating expert interviews. Adding the interviews to our existing data, we should be able to give recommendations on the future design of IS curricula in Germany.

4 Preliminary Results

First topic modeling attempts with the already preprocessed curricular data (about half of the total records of over 9,500 modules from 188 universities) showed promising results. Aligning the number of topics with the study guide of Kurbel et al. (2009), we received 47 topics that can be assigned to specific fields of competencies. An example of such a topic is “Web programming” with the following most likely occurring (translated) terms: “web applications, html, php, xml, competency, web, css, technologies, java, web architectures, data, javascript”. The topic modeling was performed in R with a package for the Java-based machine learning tool MALLETT.

Figure 3 shows the distribution of the 47 topics over the considered module corpus, weighted by the ECTS credits for each module. The data contains Bachelor (undergraduate), as well as Master (graduate) study programmes in the same ratio as in the complete corpus. The topics and their distribution already seem to represent the structure of a (combined Bachelor/Master) German IS study programme, which consists of various modules from the fields of knowledge of information systems, computer science, economics, application knowledge, soft skills and other adjacent topics like mathematics. The main fields of knowledge are represented equally and we see a focus on scientific work – due to the high average amount of credits for student theses – and other cross-sectional topics, as well as in a regular German IS curriculum. On the basis of this first results and due to the fact, that established research successfully conducted text mining methods on job advertisement data (e.g. Debortoli et al.

2014; Litecky et al. 2010), we are confident that the proposed approach and the underlying data will prove themselves suitable to solve our research questions.

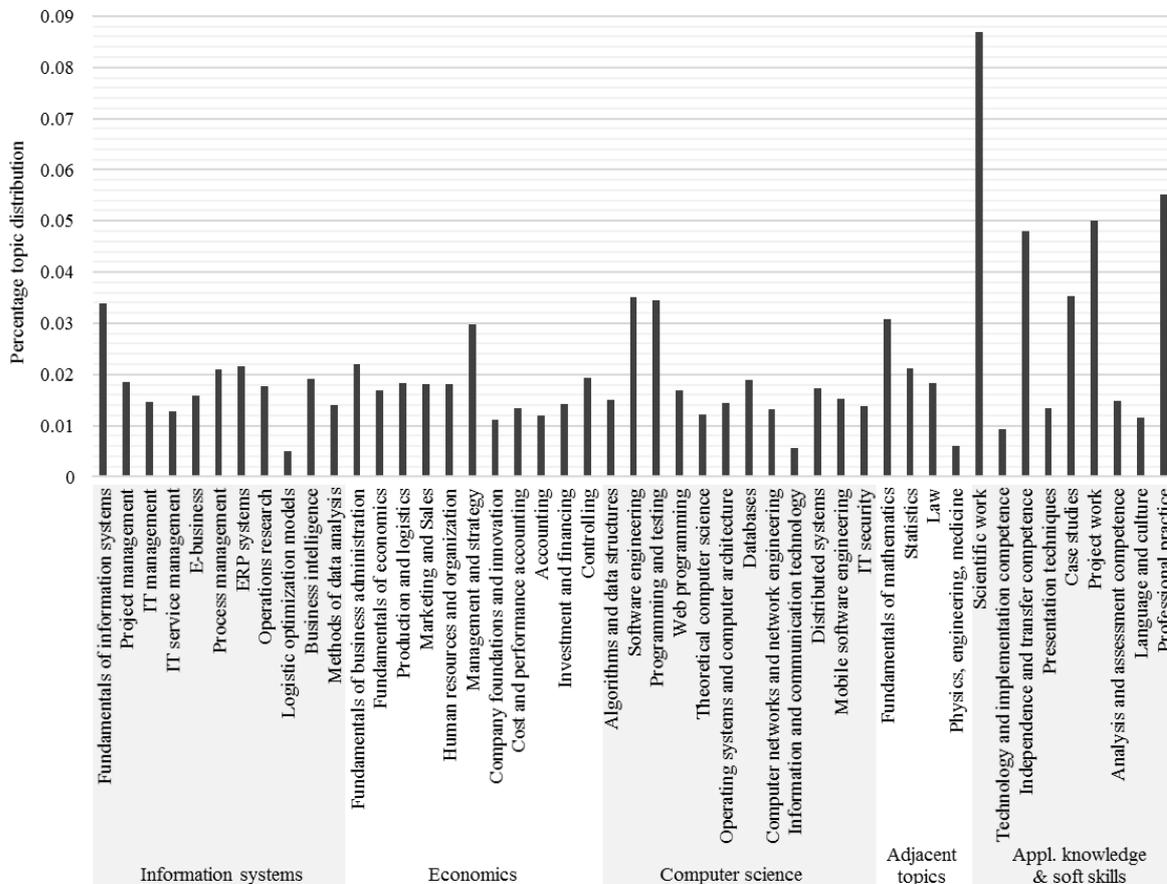


Figure 3. Percentage distribution of the topics over the considered corpus

5 Expected Contributions and Future Work

In this paper, we presented our approach of combining universities’ offerings with the required industry job skills in order to identify potential curricular gaps at course level that arise through ongoing digitalization and, as a consequence, changing skill requests for employees. We proposed an appropriate set of methods for our project including text mining methods and an expert survey and interview phase for evaluation. We gathered large amounts of German IS curricular module descriptions and offers for job starters and successfully carried out first topic modeling attempts in order to prove our concept. Our next step is now to first enlarge the document corpus by processing the remaining module manuals for topic modeling. After that we will perform topic modeling for that enlarged corpus and improve the corpus vocabulary over various iterations. The same will take place for the job advertisements corpus. Building on our results, we may identify opportunities for further research in both directions, the industry demand side and the university supply side. Possible future research covers questions like (i) the differences between a Bachelor’s and a Master’s degree and their qualification for the labour market – does a Bachelor’s degree already include the skills needed for the labour market, as requested by politics?; (ii) the development of educational offers and industry skill requirements over time – does curriculum follow industry requirements or vice versa, or is there no connection apparent?; (iii) data-driven survey on different types and locations of universities in Germany – are there differences in the curricular focus and design? As collecting and editing the needed data is a huge effort, we plan to publish our gathered data sets for future research.

References

- Alghamdi, R. and Alfalqi, K. (2015) 'A Survey of Topic Modeling in Text Mining', *Editorial Preface*, 6(1).
- Athey, S. and Plotnicki, J. (1998) 'The evaluation of job opportunities for IT professionals', *The Journal of Computer Information Systems*, 38(3), p. 71.
- Bailey, J. and Mitchell, R.B. (2006) 'Industry perceptions of the competencies needed by computer programmers: technical, business, and soft skills', *Journal of Computer Information Systems*, 47(2), pp. 28–33.
- Benamati, J.H., Ozdemir, Z.D. and Smith, H.J. (2010) 'Aligning undergraduate IS curricula with industry needs', *Communications of the ACM*, 53(3), pp. 152–156.
- Benbasat, I., Dexter, A.S. and Mantha, R.W. (1980) 'Impact of organizational maturity on information system skill needs', *MIS Quarterly*, pp. 21–34.
- Blei, D.M. (2012) 'Probabilistic topic models', *Communications of the ACM*, 55(4), p. 77. doi: 10.1145/2133806.2133826.
- Bogner, A., Littig, B. and Menz, W. (2014) *Interviews mit Experten: Eine praxisorientierte Einführung*. (Qualitative Sozialforschung). Wiesbaden: Springer VS. Available at: <http://dx.doi.org/10.1007/978-3-531-19416-5>.
- Chang, C.L.-H., Chen, V., Klein, G. and Jiang, J.J. (2011) 'Information system personnel career anchor changes leading to career changes', *European Journal of Information Systems*, 20(1), pp. 103–117.
- Cheney, P.H., Hale, D.P. and Kasper, G.M. (1989) 'Information systems professionals: skills for the 1990s', *Proceedings of the Twenty-Second Annual Hawaii International Conference*, 4, pp. 331–336.
- Chia-An, C. and Shih, S.C. (2005) 'Organizational and end-user information systems job market: An analysis of job types and skill requirements', *Information Technology, Learning, and Performance Journal*, 23(2), p. 1.
- Chrysler, E. and van Auken, S. (2002) 'Entry level value versus career value of MIS courses: Faculty expectations versus alumni perceptions', *The Journal of Computer Information Systems*, 42(3), p. 38.
- Davis, D.C. (2003) 'Job titles, tasks, and experiences of information systems and technologies graduates from a Midwestern university', *Journal of Information Systems Education*, 14(1), p. 59.
- Davis, G.B., Gorgone, J.T., Couger, J.D., Feinstein, D.L. and Longenecker, H.E. (1997) 'IS '97', pp. 1–94.
- Debertoli, S., Müller, O. and Vom Brocke, J. (2014) 'Comparing business intelligence and big data skills', *Business & Information Systems Engineering*, 6(5), pp. 289–300.
- Deerwester, S., Dumais, S.T., Furnas, G.W., Landauer, T.K. and Harshman, R. (1990) 'Indexing by latent semantic analysis', *Journal of the American society for information science*, 41(6), p. 391.
- Downey, J.P., McMurtrey, M.E. and Zeltmann, S.M. (2008) 'Mapping the MIS curriculum based on critical skills of new graduates: An empirical examination of IT professionals', *Journal of Information Systems Education*, 19(3), p. 351.
- Dwyer, C. and Knapp, C.A. (2004) 'How useful is IS 2002? A case study applying the model curriculum', *Journal of Information Systems Education*, 15(4), p. 409.
- Ehie, I.C. (2002) 'Developing a management information systems (MIS) curriculum: Perspectives from MIS practitioners', *Journal of Education for Business*, 77(3), pp. 151–158.
- European Commission (2016) *The importance of the digital economy*. Available at: https://ec.europa.eu/growth/sectors/digital-economy/importance_de (Accessed: 2 December 2016)
- European Committee for Standardization (2014) *European e-Competence Framework 3.0*. Available at: http://www.e-competences.eu/wp-content/uploads/2014/02/European-e-Competence-Framework-3.0_CEN_CWA_16234-1_2014.pdf (Accessed: 5 October 2016).

- Fang, X., Lee, S., Lee, T.E. and Huang, W. (2004) 'Critical factors affecting job offers for new MIS graduates', *Journal of Information Systems Education*, 15(2), p. 189.
- Gallivan, M.J., Truex, D.P. and Kvasny, L. (2004) 'Changing patterns in IT skill sets 1988-2003', *ACM SIGMIS Database*, 35(3), pp. 64–87. doi: 10.1145/1017114.1017121.
- Gorgone, J.T. (2006) 'Information Systems Accreditation: Preparation, Process, and Standards', *Communications of the Association for Information Systems*, 17(1), p. 19.
- Granger, M.J., Dick, G., Luftman, J., van Slyke, C. and Watson, R.T. (2007) 'Information systems enrollments: Can they be increased?'
- Hansmann, T. and Niemeyer, P. (2014) 'Big Data - Characterizing an Emerging Research Field Using Topic Models', *Web Intelligence (WI) and Intelligent Agent Technologies (IAT)*, (1), pp. 43–51. doi: 10.1109/WI-IAT.2014.15.
- Hickson, J. (2000) 'First steps to an IT career', *The Computer Bulletin*, 42(1), pp. 28–29.
- Hirschheim, R. and Klein, H.K. (2003) 'Crisis in the IS Field? A Critical Reflection on the State of the Discipline', *Journal of the Association for Information Systems*, 4(1), p. 10.
- Hofmann, T. (2001) 'Unsupervised learning by probabilistic latent semantic analysis', *Machine learning*, 42(1-2), pp. 177–196.
- HRK (2016) *Studiengangsuche*. Available at: <http://www.hochschulkompass.de/studium/suche/erweiterte-suche.html> (Accessed: 23 September 2016).
- IfM Bonn (2016) *SME-definition of IfM Bonn*. Available at: <http://en.ifm-bonn.org/definitions/sme-definition-of-ifm-bonn/> (Accessed: 28 October 2016).
- Igbaria, M., Greenhaus, J.H. and Parasuraman, S. (1991) 'Career orientations of MIS employees: an empirical analysis', *MIS Quarterly*, pp. 151–169.
- Kurbel, K., Brenner, W., Chamoni, P., Frank, U., Mertens, P. and Roithmayr, F. (2009) *Studienführer Wirtschaftsinformatik 2009 | 2010. Studieninhalte – Anwendungsfelder – Berufsbilder. Universitäten in Deutschland | Österreich | Schweiz*.
- Lee, D.M.S., Trauth, E.M. and Farwell, D. (1995) 'Critical Skills and Knowledge Requirements of IS Professionals: A Joint Academic/Industry Investigation', *MIS Quarterly*, 19(3), p. 313. doi: 10.2307/249598.
- Lee, K. and Mirchandani, D. (2010) 'Dynamics of the importance of IS/IT skills', *Journal of Computer Information Systems*, 50(4), pp. 67–78.
- Lee, S., Baker, J., Song, J. and Wetherbe, J.C. 'An empirical comparison of four text mining methods', *System Sciences (HICSS), 43rd Hawaii International Conference*, 2010, pp. 1–10.
- Leitheiser, R.L. (1992) 'MIS skills for the 1990s: A survey of MIS managers' perceptions', *Journal of Management Information Systems*, 9(1), pp. 69–91.
- Lifer, J.D., Parsons, K. and Miller, R.E. (2009) 'A comparison of information systems programs at AACSB and ACBSP schools in relation to IS 2002 model curricula', *Journal of Information Systems Education*, 20(4), p. 469.
- Litecky, C., Aken, A., Ahmad, A. and Nelson, H.J. (2010) 'Mining for Computing Jobs', *IEEE Software*, 27(1), pp. 78–85. doi: 10.1109/MS.2009.150.
- Litecky, C.R., Arnett, K.P. and Prabhakar, B. (2004) 'The paradox of soft skills versus technical skills in IS hiring', *Journal of Computer Information Systems*, 45(1), pp. 69–76.
- Maier, J.L., Greer, T. and Clark, W.J. (2002) 'The management information systems (MIS) job market late 1970s-late 1990s', *The Journal of Computer Information Systems*, 42(4), p. 44.
- McGann, S.T., Frost, R.D., Matta, V. and Huang, W. (2007) 'Meeting the challenge of IS curriculum modernization: A guide to overhaul, integration, and continuous improvement', *Journal of Information Systems Education*, 18(1), p. 49.
- Miner, G. (2012) *Practical text mining and statistical analysis for non-structured text data applications*: Academic Press.
- Nelson, H.J., Ahmad, A., Martin, N.L. and Litecky, C.R. (2007) 'A comparative study of IT/IS job skills and job definitions', *Proceedings of the 2007 ACM SIGMIS CPR conference on Computer personnel research: The global information technology workforce*, pp. 168–170.

- Nettleton, S.C., Litchfield, A.J. and Taylor, T.L. (2008) 'Engaging professional societies in developing work-ready graduates', *Proceedings 31st HERDSA Conference*, 2008, pp. 241–251.
- Noll, C.L. and Wilkins, M. (2002) 'Critical skills of IS professionals: A model for curriculum development', *Journal of information technology education*, 1(3), pp. 143–154.
- Petrova, K. and Claxton, G. (2005) 'Building student skills and capabilities in information technology and eBusiness: A moving target', *Journal of Information Systems Education*, 16(1), p. 27.
- Simon, J.C., Kaiser, K.M., Beath, C., Goles, T. and Gallagher, K. (2007) 'Information technology workforce skills: Does size matter?' *Information Systems Management*, 24(4), pp. 345–359.
- Stefanidis, A. (2014) *Undergraduate information systems in the UK: analysing curriculum skills and industry needs*. © Angelos Stefanidis.
- Stefanidis, A., Fitzgerald, G. and Counsell, S. (2013) 'IS curriculum career tracks: a UK study', *Education + Training*, 55(3), pp. 220–233. doi: 10.1108/00400911311309297.
- Stifterverband (2013) *Methodik: Der Hochschulvergleich*. Available at: <http://www.stifterverband.com/gruendungsradar/2013/hochschulbefragung/methodik/hochschulvergleich/index.html> (Accessed: 28 October 2016).
- Stolterman, E. and Croon Fors, A. (2004) 'Information Technology and the Good Life', in Kaplan, B., Truex, D.P., Wastell, D., Wood-Harper, A.T. and DeGross, J.I. (eds.) *Information Systems Research: Relevant Theory and Informed Practice*. (IFIP International Federation for Information Processing, 143). Boston, MA: Springer Science + Business Media Inc, pp. 687–692.
- Todd, P.A., McKeen, J.D. and Gallupe, R.B. (1995) 'The Evolution of IS Job Skills: A Content Analysis of IS Job Advertisements from 1970 to 1990', *MIS Quarterly*, 19(1), p. 1. doi: 10.2307/249709.
- Topi, H., Valacich, J.S., Wright, R.T., Kaiser, K., Nunamaker Jr, J.F., Sipior, J.C. and Vreede, G.-J. de (2010) 'IS 2010: Curriculum guidelines for undergraduate degree programs in information systems', *Communications of the Association for Information Systems*, 26(1), p. 18.
- Trauth, E.M., Farwell, D.W. and Lee, D. (1993) 'The IS Expectation Gap: Industry Expectations versus Academic Preparation', *MIS Quarterly*, 17(3), p. 293. doi: 10.2307/249773.
- White, G.W. (2005) 'Business information courses in LIS programs: A content analysis', *Journal of Business & Finance Librarianship*, 10(2), pp. 3–15.
- White, K.B. and Lederer, A.L. 'Panel 6 connecting: Strategies for Bridging the Gap from Education to Industry and Government', *ICIS*, 1987, p. 12.
- Wilkerson, J.W. (2012) 'An alumni assessment of MIS related job skill importance and skill gaps', *Journal of Information Systems Education*, 23(1), p. 85.
- Williams, C.L. and Pomykalski, J.J. (2004) 'Comparing current IS curricula to the IS 2002 model curriculum', *Information Systems Education Journal*, 4(76), pp. 3–10.
- Yang, S.C. (2012) 'The Master's Program in Information Systems (IS): A Survey of Core Curriculums of US Institutions', *Journal of Education for Business*, 87(4), pp. 206–213.