

# Educational pathways in a German labor market knowledge graph

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**Abstract:** Educational pathways play a pivotal role in fostering lifelong learning and skilled workforces. We build upon a German labor market knowledge graph that was developed from the German Labor Market Ontology (GLMO). The GLMO provides entities for qualifications, such as occupations and training programs, as well as tools and skills. To conduct research on educational pathways, we employ several graph algorithms, such as shortest paths, and present the results. It is possible to demonstrate the advantages of digital methods in sociological research, thereby advancing the boundaries of computational social sciences in labor market research.

**Keywords:** Pathfinding, Shortest Paths, Labor Market research, Knowledge Graphs, Ontologies, Computational Social Sciences

## 1 Introduction

Knowledge graphs and ontologies represent a powerful set of tools for the prediction and modeling of labor demands, as well as the analysis of occupational roles and the forecasting of unemployment rates [Dö23; DWB22; He16]. Such resources provide a valuable support system for policy makers, education providers, employers, and career counselors in their efforts to navigate the complexities of the labor market ecosystem. One example is the European Labor Market Ontology ESCO, which has been utilized to facilitate a transparent matching between candidates and vacancies. The explicit modeling of knowledge enables a clear and understandable explanation of how this recommendation system functions [DVP15; Jo17].

Despite the apparent benefits of this type of knowledge graphs for Continuing Vocational Education (CVET) programs, there remains a paucity of its implementation [Re22]. The development of ontologies has been informed by a number of sources, including the recently developed German Labor Market Ontology (GLMO) [Dö23], as well as publicly available sources from the BA, such as the Classification of Occupations 2010. The 2020 version is designated as the "Klassifikation der Berufe 2010 Fassung 2020" (KldB) and is available in German. Alternatively, the "Kurznachrichtensystem für die berufliche Weiterbildung" (KURSNET) database may be consulted [FD24].

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The overarching research question of this paper is to identify educational pathways in a knowledge graph  $G = (V, E)$  that include occupations, (continuing) vocational education programs, study programs, and the outcomes of these programs. To evaluate our approach, we focus on two research questions: First, given an occupation  $x \in V$ , what are all possible educational pathways  $[v_1, \dots, v_n]$  with  $v_n = x$ . Secondly, for a given training  $y \in V$ , it is necessary to identify all possible educational pathways  $[v_1, \dots, v_n]$  with  $v_1 = y$ .

## 2 Methodological approach

The knowledge graph, based on GLMO and BA relations, is stored in a Neo4j database. This enables the use of Cypher queries to compute and enumerate subgraphs. Pathfinding is employed to identify all paths from a node to all others, if they exist, see [Dö22; FD24]. Additionally, all-shortest-pairs algorithms are applied to detect shortest paths. The interpretation of these results and their computational implications will be discussed.

## 3 Conclusions and Outlook

In this paper, we enrich the GLMO using publicly available BA data to create a knowledge graph. We demonstrate that this approach can be used to enumerate educational pathways, emphasizing the significance of data science methods for labor market research and computational social sciences. However, this method is constrained by the availability of data. It excludes the vast scope of unregulated continuing education. The central importance of continuing vocational training and lifelong learning has been increasingly addressed by policymakers in Germany [Sc22]. The German education system offers different pathways for professionals in tertiary education [GL21]. It is therefore necessary to distinguish between initial vocational education (training, Ausbildung, or retraining, Umschulung) and continuing vocational education. Continuing vocational education encompasses advanced training (Weiterbildung, unregulated, e.g., continuing professional development) and upgrading training (Fortbildung). Upgrading training is predominantly regulated, whereas advanced training is comparatively less regulated. A total of 1,004 (re-)trainings are subject to regulation by enterprises or the Crafts and Trade Code, with 542 of these being subject to regulation by the German state. The number of informal trainings is considerably higher.

In addition to these limitations, the benefits of occupational metadata will be discussed, including activity fields and alternatives, CVET hierarchies, the addition of fine-grained skills, and the addition of relationships from fine-grained occupations to skills, CVET, or alternatives and suggestions.

## References

- [Dö22] Dörpinghaus, J. et al.: From social networks to knowledge graphs: A plea for interdisciplinary approaches. *Social Sciences & Humanities Open* 6/1, p. 100337, 2022.
- [Dö23] Dörpinghaus, J. et al.: Towards a German labor market ontology: Challenges and applications. *Applied Ontology* 18(4), pp. 1–23, 2023.
- [DVP15] De Smedt, J.; le Vrang, M.; Papantoniou, A.: ESCO: Towards a Semantic Web for the European Labor Market. In: *Ldow@ www*. 2015.
- [DWB22] Dörpinghaus, J.; Weil, V.; Binnewitt, J.: Towards the Analysis of Longitudinal Data in Knowledge Graphs on Job Ads. In: *The Workshop on Computational Optimization*. Springer, pp. 52–70, 2022.
- [FD24] Fischer, A.; Dörpinghaus, J.: Web Mining of Online Resources for German Labor Market Research and Education: Finding the Ground Truth? *Knowledge* 4/1, pp. 51–67, 2024.
- [GL21] Graf, L.; Lohse, A. P.: Advanced skill formation between vocationalization and academization: The governance of professional schools and dual study programmes in Germany. *Governance Revisited. Challenges and Opportunities for Vocational Education and Training*; Gonon, P., Bürgi, R., Eds/, 2021.
- [He16] Helmrich, R. et al.: Digitalisierung der Arbeitslandschaften: keine Polarisierung der Arbeitswelt, aber beschleunigter Strukturwandel und Arbeitsplatzwechsel. *Wissenschaftliche Diskussionspapiere*, 2016.
- [Jo17] Jones, D.: *ESCO handbook: European skills, competences, qualifications and occupations*. Publication Office of the European Union, Luxembourg, 2017.
- [Re22] Reichow, I. et al.: *Recommendersysteme in der beruflichen Weiterbildung. Grundlagen, Herausforderungen und Handlungsempfehlungen. Ein Dossier im Rahmen des INVITE-Wettbewerbs*, 2022.
- [Sc22] Schiersmann, C.: *Weiterbildungsberatung im Kontext der Nationalen Weiterbildungsstrategie: Finanzielle und strukturelle Aspekte*. *Hessische Blätter für Volksbildung* 72/1, pp. 43–53, 2022.