

Wilhelm-Weidner, Arno; Vogel-Adham, Elke; Reichow, Insa; Rashid, Sheikh Faisal; Hübsch, Thomas; Hochbauer, Monica

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Kontakt / Contact:

peDOCS
DIPF | Leibniz-Institut für Bildungsforschung und Bildungsinformation
Informationszentrum (IZ) Bildung
E-Mail: pedocs@dipf.de
Internet: www.pedocs.de

Mitglied der


Leibniz-Gemeinschaft



Arno Wilhelm-Weidner, Elke Vogel-Adham, Insa Reichow, Sheikh Faisal Rashid,
Thomas Hübsch, Monica Hochbauer

Use of ESCO in Digital Vocational Education and Training – Insights from the projects of the German Funding Program “Innovationswettbewerb INVITE”

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**Arno Wilhelm-Weidner, Elke Vogel-Adham, Insa Reichow, Sheikh Faisal Rashid,
Thomas Hübsch, Monica Hochbauer**

The joint contact address of the authors: digitalbegleitung@vdivde-it.de

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Short Summary

The paper examines the application and adaptation of the competency classification system "ESCO," drawing on practical experiences gained from specific use cases within vocational education. To explore this topic, a survey was conducted and analyzed among projects funded by the German funding program INVITE. The paper discusses the need for ESCO to adapt as a result of the projects as well as the challenges and opportunities for further development in this area.

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1 Introduction

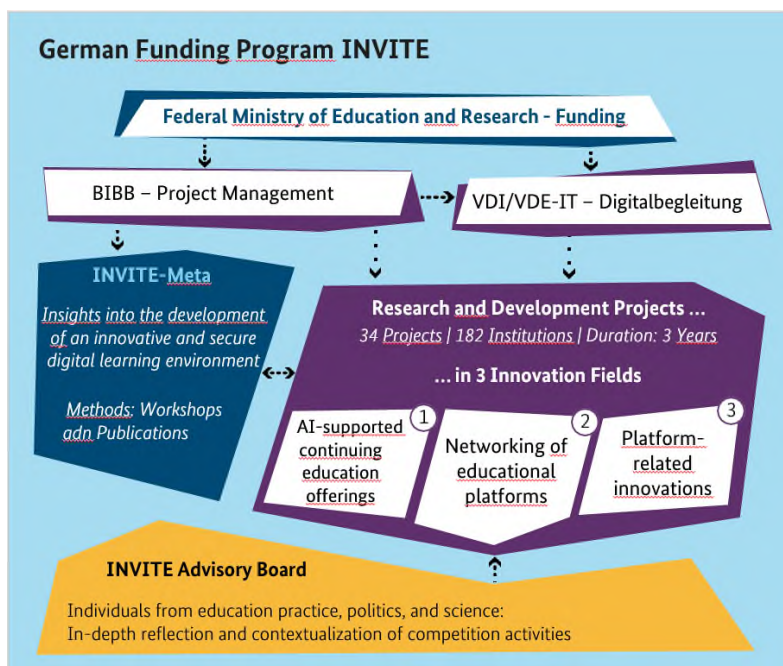
Effective digital education frequently requires a reliable mapping of competencies and skills. This ensures that educational resources can be assessed, easily found, and matched accurately with learners' needs. Within the German funding program INVITE, the ESCO classification has been successfully utilized as a basis for these tasks. The extensive use of ESCO across various INVITE projects has revealed both its advantages and challenges, highlighting areas where further development is possible. These challenges involve not only integrating ESCO into existing educational structures but also regularly updating it to reflect evolving job demands and market conditions.

In this paper, we provide a comprehensive overview of how various projects in INVITE have employed ESCO. Additionally, we analyze the strengths and challenges of ESCO, and discuss possibilities for its future development and potential new applications.

1.1 Brief Overview: What is INVITE?

The German funding program INVITE, embedded in the National Skills Strategy (NWS), is an initiative launched by the Federal Ministry of Education and Research (BMBF). It has been funding 34 research and development projects, along with a scientific accompanying project ("INVITE-Meta"), from 2021 to 2025. A total of 182 institutions from various industries and disciplines, involving over 400 experts, have collaborated to create an innovative and secure digital learning environment (BIBB, n.d.). The goal of INVITE is to enable individuals interested in continuing education to easily find suitable digital learning opportunities that match their needs and life circumstances.

The funded projects facilitate the search for suitable training programs, enhance user-centered design



in educational platforms, and expand the range of AI-supported continuing education offerings¹. The German Federal Institute for Vocational Education and Training (BIBB) has been commissioned to provide technical and administrative support for the program, with additional support from technological monitoring and research conducted by 'Digitalbegleitung' (VDI/VDE-IT) and scientific support provided by 'INVITE-Meta' (mmb Institute and DFKI) (BIBB, n.d.).

This paper has been co-authored by Digitalbegleitung and INVITE-Meta.

Figure1 : Overview of the components of the German funding program INVITE. Source: Federal Institute for Vocational Education and Training

¹ <https://www.invite-toolcheck.de/html/de/Uber-INVITE.php>

1.2 Overview - Description of ESCO

Various classification systems can be utilized to categorize competencies or educational opportunities, such as the Classification of Occupations and the Documentation Code Database (DKZ) of the German Federal Employment Agency (Bundesagentur für Arbeit, 2024), or the American O*Net system (Riedel & Stark, 2023). Currently, the ESCO classification of the European Union is considered the most promising approach for digital education projects for various reasons (ibid., p. 21).

ESCO (European Skills, Competences, Qualifications, and Occupations) is a European classification system that connects skills, competencies, qualifications, and occupations. It is being developed as part of a project led by the Directorate-General for Employment, Social Affairs, and Inclusion (DG EMPL) of the European Commission.

ESCO aims to enhance the transparency and comparability of educational and professional qualifications across Europe, thereby fostering occupational mobility. ESCO is accessible through an online portal. Standardization is carried out within a multilingual online database (available in 28 languages, featuring over 3,000 occupations and nearly 14,000 skills), which is continuously updated to align with evolving labor market requirements, including changes in learning content and terminology in education and training programs.

Digital systems can integrate ESCO via an ESCO API to offer services such as skill-based job matching or personalized recommendations on online platforms. Feedback, suggestions, and proposals from organizations and ESCO stakeholders regarding content and organizational improvements are regularly integrated into ESCO for continuous enhancement (European Commission, 2025).

The Commission identifies the following advantages:

- **Use of ESCO in online applications and platforms**, enabling suitable job offers or training opportunities based on skills and qualifications.
- **Competence-based job placement**: ESCO provides standardized descriptions of occupations and skills, facilitating the matching of job seekers with appropriate employment.
- **Bridging education and work**: ESCO helps education providers tailor their programs to labor market demands and enables employers to better understand educational content.
- **Connecting labor markets and promoting mobility**: ESCO enhances cross-border communication regarding skills, education, and employment, and supports job seekers throughout Europe via integrated platforms.

1.3 Use of ESCO in Vocational Education and Training

During the duration of the INVITE projects, participants were surveyed about the metadata standards they utilized (Goertz et al., 2023). ESCO was employed by the projects as a comprehensive metadata standard serving various purposes, such as classifying learning opportunities, presenting course offerings, enabling course searches and enrollments, and issuing educational certificates. In particular, ESCO was particularly used to describe competencies already possessed by learners, those conveyed through educational offerings, and those certified upon course completion.

The MyEduLife project, in particular, intensively applied and studied the use of ESCO. In a case study, project staff reported that ESCO is a useful instrument for documenting the learning outcomes of further education in a comparable and transparent manner (Riedel, Stark & Neumann, 2023). At the same time, however, mapping competencies - i.e., assigning competency descriptions such as those found in course descriptions to specific ESCO competencies - required considerable effort and did not always result in a reliable and valid representation of learning outcomes (Riedel & Stark, 2023).

Furthermore, the initial survey of INVITE projects conducted in 2023 highlighted the challenge of adequately representing the diversity of professional competencies and qualifications across different countries and industries. Since definitions of skills and competencies vary depending on context, this led to ambiguities, inconsistencies, or gaps in the datasets. Initial AI-based approaches have been developed to address these issues, including automated tagging of courses using ESCO competencies (cf. Hübsch et al., 2024; Rashid et al., 2024) and automated matching of learning outcomes with ESCO competencies (Zagler & Riedel, 2023).

As the funding period for the INVITE projects has now concluded, this survey of all projects will determine whether and in what form ESCO was utilized. Additionally, the survey aims to capture insights gained by the projects regarding the practicality and potential improvements of the framework.

1.4 Objectives and Key Research Questions

Workshops and surveys conducted during the INVITE program frequently indicated that the projects used ESCO in various contexts. This study aims to provide a clearer understanding of the specific ways the ESCO classification has been applied within these projects. Based on this aim, the following research questions were formulated:

- (1) Did the INVITE projects utilize existing classifications of professional competencies and qualifications?
- (2) To what extent and with what outcomes was ESCO employed for this purpose?
- (3) How and for which purposes was ESCO implemented into the platforms or applications?
- (4) What challenges arose during the implementation of ESCO?
- (5) What changes should be made to ESCO to improve the applicability of the classification?

2 Methodology

The survey conducted among the INVITE projects was designed as an online study featuring a combination of closed and open-ended questions.

2.1 Questionnaire

The questionnaire comprised nine questions concerning the use of ESCO in the project, challenges encountered during its application, technical implementation, and recommendations for further development. The complete questionnaire is provided in the appendix.

2.2 Data collection

The survey was conducted online using SoSci Survey and was accessible for a period of four weeks (25 November 2024 – 21 December 2024). All (former) employees of the INVITE projects were invited to participate via personalized email. Participation was voluntary, and all respondents provided consent for the storage and use of their responses. The collected data was anonymized and stored securely.

2.3 Participants

Participants included project managers, educators, technical developers, and other individuals actively involved in an INVITE project. A total of 67 people from 24 projects participated in the survey. Of these respondents, 36 individuals indicated that ESCO was utilized across 14 projects. Additionally, 6 participants reported that 5 projects employed an alternative classification system for professional competencies and qualifications. The remaining respondents indicated that ESCO was not used in their projects. In several instances, multiple respondents from the same project provided varying responses. This is particularly attributable to their involvement in different subprojects across multiple institutions, leading to diverse perspectives regarding the use of ESCO within a single project.

2.4 Evaluation

The data collected using SoSci Survey was analyzed as follows:

Quantitative Analysis: Responses to closed-ended questions were quantitatively analyzed to determine the frequency of ESCO usage or the use of other competency instruments.

Qualitative Analysis: Open-ended responses were qualitatively analyzed to gain detailed insights into implementation challenges, project-specific applications, and recommendations for the further development of ESCO.

2.5 Limitations

The results are based on information provided by project participants within the context of the INVITE program and are therefore not representative of the broader vocational education and training ecosystem in Germany. Nevertheless, due to the innovative nature of these projects, the results offer valuable guidance for the future application of ESCO.

3 Results

Fourteen projects reported using ESCO. In contrast, five projects indicated using a different classification system. Reasons provided included that ESCO was neither specific nor pragmatic enough for the respective tasks, and too general to adequately cover the project's use cases. Responses from projects not utilizing a comparable classification system are not relevant for further analysis.

In the following section, the focus will therefore be on how ESCO was applied, in accordance with the research questions outlined above.

3.1 How Was ESCO Used?

The use of ESCO covers a wide range of applications. Below is a summary of the results according to different areas of application:

Classification and Categorization of Learner Competency Profiles

ESCO was used to systematically classify and categorize competency profiles of learners in vocational education and training. Qualification descriptions were created using the ESCO framework. Additionally, learners' prior knowledge was standardized by assigning relevant vocational skills using the ESCO classification.

Extracting ESCO Competencies from Vocational Education and Training Program Descriptions

ESCO was applied to extract, standardize, and document competencies from vocational education and training program descriptions. The goal was to ensure that the skills gained in these courses were aligned with the ESCO classification, making them comparable within the standardized framework. One project developed an AI tool that recommends appropriate ESCO skills for learning objectives, significantly simplifying the competency description process. Additionally, modern technologies such as Large Language Models (LLMs) were used to extract competencies directly from course descriptions and link them to the appropriate ESCO categories. An example of ESCO's application was mapping the competencies of participants in commercial specialist courses. The Handelsfachwirt (Commercial Specialist) curriculum was systematically transferred into the ESCO database, ensuring structured classification of its competencies.

Matching Learner Competencies with Training Programs

Another key application of ESCO was the alignment of individual learner competencies with relevant training programs. Machine learning was used to match existing competencies with those required in various training programs. For instance, an NLP-powered service was developed to automatically annotate ESCO competencies, making it easier to conduct skill-based searches. In the WISY@KI project, the objective was to develop an AI-driven system that intelligently matches users' biographical data and competencies with suitable training opportunities. This system was implemented on the continuing education portals of Schleswig-Holstein and Hessen. AI tools were used to generate recommendations for courses and training programs based on the ESCO database.

Career Matching Based on ESCO Competencies

ESCO was instrumental in structuring occupations and systematically mapping skills to job profiles. This allowed career recommendations to be tailored based on competency profiles, including interdisciplinary future skills. AI-driven systems were also used to generate personalized career suggestions.

Competence Description in Competency Models

ESCO was used to describe competencies in competency models and to develop competency models by consolidating classical approaches. For the development of serious game prototypes, an existing competency model was adapted in such a way that the competencies could be measured in the game. The project explored ways to integrate ESCO competencies and their variations into the gaming framework.

Integration of ESCO Skills in Digital Certificates

ESCO skills were also embedded in digital certificates, making them machine-readable for automated processing and reuse. Additionally, ESCO competencies were linked to the ESCO database, allowing their seamless integration into EUROPASS.

ESCO Competencies as Metadata and for Cross-Platform Exchange

The ESCO competencies were used as metadata to map professional skills. Additionally, the ESCO API was integrated into various projects to facilitate the exchange of competency profiles across different learning platforms.

Generation of Artificial Data for Machine Learning

ESCO was used to generate artificial data. For example, as an initial “Skill Cloud Database” for a machine learning model for role “Qualification”, or to train a machine learning process to determine term similarities.

Competency-Based Assessment and Task Classification

ESCO competencies were applied to classify exercises and assessment tasks. This enabled targeted task assignment to individuals with lower proficiency in specific skills. Additionally, ESCO competencies served as a measurement framework in soft skills assessments.

3.2 Advantages, Potential, and Impact of ESCO

The survey highlighted several key advantages of ESCO, including the ability to search for specific competencies and qualifications, as well as the option to export data in JSON format for seamless further processing. Additionally, multiple respondents emphasized that ESCO offers direct API interfaces for integrating and utilizing data, an option not available in other competency classifications. This transparency and ease of data handling make ESCO particularly appealing.

Overall, most projects that implemented ESCO agreed that it was successfully integrated. Educational institutions recognize its potential to improve the comparability of qualifications but currently find the required effort too high. Employers see added value in using ESCO for hiring criteria, while users appreciate its utility in evaluating their own qualifications. Furthermore, ESCO has proven to be a valuable tool for annotating competency profiles and has served as a strong foundation for developing an extended nomenclature of competencies.

The implementation of ESCO across projects delivered the anticipated results. It provided a robust basis for defining job roles and enabled the successful realization of key functionalities and recommendations. While ESCO has proven to be a valuable resource, its implementation has also presented numerous challenges, which will be discussed in the following section. The overall impact of ESCO depends significantly on its wider adoption. A comprehensive impact assessment would require a large-scale study to statistically evaluate learning effects.

3.3 What Problems Were Reported When Using ESCO?

Few technical issues were reported. These included dead links on the website, gaps in the API documentation, and the complexity of queries within ESCO.

However, non-technical issues were considerably more significant. Many respondents pointed out that ESCO does not align well with the German vocational education system. A major concern was the inconsistent quality of the stored data. The number of skills assigned to each occupation varied widely, leading to an uneven level of detail, which was also reflected in job classifications. Some competencies were too vague, while others were overly specific. For instance, one project highlighted that "peeling an apple" was listed as a competency for the profession of "cook."

Another key issue was that ESCO does not indicate the effort required to acquire specific competencies, making it difficult to compare them. Respondents also noted gaps in job descriptions and missing entries, particularly for professions outside the IT sector. Additionally, transversal skills were not adequately represented. The hierarchical structure of different classification levels also caused difficulties, as it was sometimes overly detailed and, at other times, too superficial.

3.4 How Was ESCO Supplemented/Modified?

Several projects adapted ESCO to better fit their specific use cases. The modifications included:

- Integrating Verbis technical competencies
- Incorporating interdisciplinary future skills
- Expanding competency descriptions
- Enhancing ESCO with a knowledge graph incorporating data from job postings

Another project modified ESCO by aligning it with KldB 2010 and other competency frameworks. One project reduced the number of skills assigned to each occupation, while another optimized ESCO for machine learning by refining terminology and merging similar competencies.

3.5 What Improvements Were Suggested for ESCO?

The projects surveyed expressed several suggestions for improving ESCO. A key request was to refine the descriptions of transversal skills and revise competency profiles for greater clarity and consistency. Additionally, there was a demand for more German-language competency entries, especially for vocational training professions. To enhance machine processing, respondents suggested structuring ESCO into separate files for skills/competencies, qualifications, and occupations. Standardizing data quality was another important concern. A proposed ESCO-Slim version could consolidate duplicates and similar skills to achieve a higher level of abstraction. Transparency in ESCO's future development was also a priority. It was recommended that competency mappings be made more transparent and comparable. Another proposal was to introduce a dedicated category for cross-cutting topics - such as sustainability, digitalization, and AI skills - that would be relevant across all industries. Lastly, respondents called for an improved AI interface to simplify and enhance skill discovery.

4 Discussion and Outlook

The survey results indicate that the ESCO framework was largely successfully utilized in the INVITE program for various use cases. While ESCO's technical functionality was widely praised, criticism focused primarily on content-related issues, especially the inconsistent level of detail in competency descriptions across different occupations.

To ensure that ESCO remains equally effective across diverse applications and vocational fields, several revisions are necessary. Beyond the explicitly stated requests, additional development needs and recommendations can be derived from the survey findings. A key priority is standardizing data quality and enhancing interoperability with the DKZ (the classification system of the German Federal Employment Agency) and other competency frameworks.

Throughout the INVITE program, the ESCO Secretariat has demonstrated a strong commitment to further developing ESCO and integrating user feedback². A more flexible approach to interoperability - or even a modular integration - could make competency models more adaptable for adaptive learning. Currently, many classification systems are highly domain-specific, limiting their applicability beyond their original contexts. Ensuring the continued reusability of ESCO data remains crucial. While its current usability has been positively noted, further refinements could make the classification even more accessible and practical.

In adaptive learning, continuously aligning learners' current skill levels with relevant learning materials is essential for generating accurate recommendations. ESCO has proven to be a solid foundational classification system within the INVITE projects. However, where ESCO falls short as a general model, specialized models could serve as alternatives. Additionally, improving data quality would allow ESCO to be applied more flexibly in these contexts.

Future research should focus on enhancing the automated alignment of competency descriptions with learning content. Furthermore, the modular concept for improving classification interoperability should be explored in greater detail. The broad use of large language models (LLMs) in the INVITE projects presents further opportunities for expansion. In-depth studies are needed to determine how LLM-based assessments compare to traditional evaluations and exams. Given feedback from the projects, researchers should also investigate whether LLMs could semi-automate the improvement of ESCO's data quality.

Additionally, LLMs could support (semi-)automated trend analysis to identify emerging professions and skill demands, thereby expediting expert-led updates. By analyzing job postings, employment platforms, and academic publications, LLMs could automatically detect new job titles and propose new occupational categories.

Furthermore, predictive analytics could be integrated into ESCO to simulate future occupational trends, forecast skill demands based on global labor market data, and equip professionals with the skills needed for evolving job markets. An automated training recommendation system could help employees proactively acquire the qualifications necessary for future career advancements.

Looking ahead, substantial advancements in the classification of professional skills and competencies can be expected. Through their work, the INVITE projects have made a significant contribution to advancing the current landscape of competency frameworks.

² See e. g. <https://esco.ec.europa.eu/en/news/myedulife-project-using-esco-improved-vocational-training-transparency-and-comparability>

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6 Appendix: Questionnaire on the use of ESCO

Question 1: Have you used ESCO or another classification of vocational competencies and qualifications in your project?

m	Yes, ESCO -> <i>continue with question 2</i>
m	Yes, something else -> <i>see question 1.1</i>
m	No -> <i>end of survey</i>

Question 1.1: Which classification did you use and how was it applied?

Question 1.2: Why did you decide against ESCO?

→ *End of survey*

Question 2: How was ESCO used in your project as part of INVITE? *If possible, please also describe the technical implementation.*

Question 3: What difficulties did you encounter when using ESCO?

Question 4: Were the expected effects achieved?

Question 5: Were you able to use ESCO unchanged or did you have to make changes? What were the nature of these changes, if any were necessary?

Question 6: What challenges have you encountered when implementing ESCO classifications in your project?

Question 7: How could ESCO be modified to be usable for your project without revisions?

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Question 8: Was ESCO integrated into digital platforms or tools in your project (e.g. learning management systems, recommendation systems)?

m	Yes, namely _____
m	No

Question 9: Is there anything else you would like to tell us?

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End of the survey.