BIBB SPECIALIST PAPERS ON VET

Ralf Hermann | Hannelore Kress | Julia Olesen (Eds.)

Evidence-Based VET Policy Through Data Reporting and Data Science

Federal Institute for Vocational Education and Training

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Abbreviations

4IR	Fourth Industrial Revolution
AAQ	VET Entry Rate (German: Ausbildungsanfängerquote)
ABR	Annual Budget Reviews
ACTVET	Abu Dhabi Centre for Technical and Vocational Education and Training
ADD	Data-driven Approach
AECID	Spanish Agency for International Development Cooperation
AED	Business Association for Development
AHS	Academic Secondary Schools (Allgemeinbildende Höhere Schulen, Austria)
AI	Artificial Intelligence
AIMS	African Institute for Mathematical Sciences
ANOVA	Analysis of Variance
APR	Annual Performance Reviews
AQ	VET Participation Rate (German: Ausbildungsbeteiligungsquote)
AWS	Amazon Web Services
AZOFRAS	Association of Free Zone Companies of Costa Rica
BA	Federal Employment Agency (Bundesagentur für Arbeit, Germany)
BBiG	Vocational Training Act (Berufsbildungsgesetz, Germany)
BETALHS	Basic Education and Technical, Agricultural and Livestock High School
BHS	Colleges for Higher Vocational Education (Berufsbildende Höhere Schulen, Austria)
BIBB	Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung, Germany)
BMBF	Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, Germany)
BMS	Schools for Intermediate Vocational Education (Berufsbildende mittlere Schulen, Austria)
BTALHS	Basic Technical, Agriculture, Livestock High School
CAD	Computer-Aided Design
CAP	Advisory and Promotional Commission for dual education and training
CAP – DUAL TVET	Advisory and Promotion Commission for Dual TVET
CBT	Competency-Based Training
CCNU	Central China Normal University

CCSS	Costa Rican Social Security Fund
CEDEFOP	European Centre for the Development of Vocational Training
CICR	Chamber of Industries of Costa Rica
CINTERFOR	Inter-American Centre for Knowledge Development in Vocational Training
CNC	Computer Numerical Control
CONAPE	National Commission for Education Loans
CONARE	National Council of University Rectors
CONESUP	National Council of Private University Higher Education
COVAO	Vocational School of Arts and Trades
COV-CAINA	Institutional Call Centre
CoVEs	Centres of Vocational Excellence
CRI	Centres for Research and Innovation
CSE	Higher Council of Education
CTVET	Commission for Technical and Vocational Education and Training
D_AP	Learning
D_DO	Demand x Supply
D_GE	Generations
D_IE	Strategic Indicators
D_MA	Agroindustry Market
D_MTI	Industrial Work Map
D_PD	People with Disabilities
D_RE	Race and Ethnicity
D_SI	Integrating Solution
D-A-CH	Germany (D), Austria (A), Switzerland (CH)
DAIP	Department Annual Implementation Plan
DBpia	DataBase Periodical Information Academic
DBR	Design-Based Research
DC dVET	Donor Committee for Dual Vocational Education and Training
DEVAL	German Institute for Development Evaluation
DID	Decentralized Identifier
DMR	Departmental Monitoring Report
DPL	Data Protection Law
DTVET	The Department of Technical and Vocational Education and Training
DVET	Directorate of Vocational Education and Training (former, under MOLISA)

DWD	Department of Workforce Development (Wisconsin)
EAfA	European Alliance for Apprenticeships
EaP	Eastern Partnership
EBSI	European Blockchain Services Infrastructure
EDM	Educational Data Mining
EFTP	Technical and Vocational Education and Training (TVET)
EQAVET	European Quality Assurance in Vocational Education and Training
EU	European Union
EUDI Wallet	European Digital Identity Wallet
FDV	Federal Diploma of Vocational Education and Training (Switzerland)
FOAIE	Faculty of Artificial Intelligence in Education
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GES	Health, Education and Social service (occupations)
GIZ	German Agency for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GOVET	German Office for International Cooperation in Vocational Education and Training
GTC	Government Technical College/Government Technological College
GTHS	Government Technical High School
GTI	Government Technical Institute/Government Technological Institute
GWS	Institute of Economic Structures Research (Gesellschaft für Wirtschaftliche Strukturforschung)
HEEQ	Higher education entrance qualification
HRDK	Human Resources Development Service of Korea
HwO	Crafts and Trade Code (HwO – Handwerksordnung, Germany)
IAB	Institute for Employment Research (Institut für Arbeitsmarkt- und Berufsforschung, Germany)
ibw	Institut für Bildungsforschung der Wirtschaft (Austria)
ICT	Information and Communication Technology
IDAP	Professional Assessment Performance Indicator
IDP	Internally Displaced Person
IHK	Chamber of Industry and Commerce (Industrie- und Handelskammer, Germany)
ILO	International Labour Organization
INA	National Institute of Apprenticeship OR National Institute of Learning

INIE	Institute for Educational Research
INS	National Insurance Institute
IoT	Internet of Things
IPFS	InterPlanetary File System
IR 4.0	The Fourth Industrial Revolution
JDoI	Joint Declaration of Intent
KAS	Konrad Adenauer Foundation
KISS	Korean studies Information Service System
KOICA	Korea International Cooperation Agency
KPIs	Key Performance Indicator
KRIVET	Korea Research Institute for Vocational Education and Training
KT	Knowledge Transfer
KTS	Knowledge Transfer Strategy
LM	Labour Market
LMI	Labour Market Information
LMIS	Labour Market Information System
LMS	Learning Management System
M&E	Monitoring and Evaluation
MEIC	Ministry of Economy, Industry and Commerce
MENA	Middle East and North Africa
MEP	Ministry of Public Education
MICITT	Ministry of Science, Innovation, Technology and Telecommunications
ML	Machine Learning
MOE	Ministry of Education (People's Republic of China)
MoES	Ministry of Education and Science of Ukraine
MOET	Ministry of Education and Training (Vietnam)
MOLISA	Ministry of Labour – Invalids and Social Affairs (Vietnam)
MOOC	Massive Open Online Course
MOST	Ministry of Science and Technology
MTR	Mid-Term Review
MTSS	Ministry of Labor and Social Security
NDSL	National Discovery for Science Leaders
NESP	National Education Strategic Plan
NGOs	Non-Governmental Organizations
NIVT	National Institute of Vocational Education and Training (Vietnam)

NLP	Natural Language Processing
NQA	National Qualifications Authority (United Arab Emirates – UAE)
NVTI	National Vocational Training Institute
OBEFOTEP	Thematic Observatory of Technical and Vocational Education and Training
OBS SFUVET	Swiss Observatory for Vocational Education and Training
OECD	Organisation for Economic Co-operation and Development
OEI	Organization of Ibero-American States
öibf	Austrian Institute for Research on Vocational Education and Training
OID4VC	OpenID for Verifiable Credentials
OIT	International Labour Organization (ILO)
PDF	Portable Document Format
PoC	Proof of Concept
PPP	Public-Private Partnerships
QR code	Quick Response code
R & D	Research and Development
RAPIDS	Registered Apprenticeship Partners Information Database System
REST API	Representational State Transfer Application Programming Interface
RISS	Research Information Sharing Service
RN	Registered Nurse
ROI	Return on Investment
SDGs	Sustainable Development Goals
SDK	Software Development Kit
SEC	Smart Education of China OR Costa Rican Educators Union
SENAI	National Industrial Learning Service (Serviço Nacional de Aprendizagem Industrial, Brazil)
SERI	State Secretariat for Education, Research and Innovation
SETs	Specific Emerging Technologies
SFUVET	Swiss Federal Institute for Vocational Education and Training
SINEFOTEP	National System of Technical and Vocational Education and Training
SINETEC	Integrated National Education System for Competitiveness
SIP	Schools and Industry Partnership
SKBF	Schweizerische Koordinationsstelle für Bildungsforschung (Swiss Coordination Centre for Educational Research)
SMART	Specific, Measurable, Achievable, Relevant and Time-bound
SMEs	Small and Medium-sized Enterprises

SPSS	Statistical Package for the Social Sciences
SSI	Self-Sovereign Identity
STEM	Science, Technology, Engineering, and Mathematics
STISP	Science, Technology and Innovation Strategic Plan
ToC	Theory of Change
TTTC	TVET Teacher's Training College
TVET	Technical and Vocational Education and Training
UCCAEP	Costa Rican Union of Chambers and Private Business Associations
UCR	University of Costa Rica
UI	Unemployment Insurance OR User Interface
UMFCCI	Union of Myanmar Federation of Chambers of Commerce and Industry
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-UNEVOC	UNESCO's International Centre for Technical and Vocational Education and Training
UNFPA	UN Population Fund
UNICEF	United Nations International Children's Emergency Fund
UTN	National Technical University
VET	Vocational Education and Training
VocEx	Vocational Excellence
VR	Virtual Reality
VS	Vocational School
W3C	World Wide Web Consortium
WASCAL	West African Science Service Centre on Climate Change and Adapted Land Use
WFD	Workforce Development
WFP	World Food Program

Preface

Dear readers,

in today's rapidly changing world, there is an urgent need for skilled workers. Vocational education and training plays an important role in shaping the future of individuals, economies, and societies. In view of the challenges posed by globalisation and technological advances, the effective use of data is key to innovation in vocational education and training systems. Data enables policymakers, educators, and researchers to make evidence-based decisions that meet the needs of learners while keeping the long-term success of vocational education and training in mind.

Data has always played a central role in the mission and activities of the Federal Institute for Vocational Education and Training (BIBB). As a German research institute and centre of excellence for vocational education and training, the BIBB processes large amounts of data in its research data centre, publishes the annual data report as a supplement to the Federal Government's vocational education and training report, and conducts long-term studies, for example, on occupational and qualification developments.

This volume brings together 32 contributions from experts from 16 countries. They offer valuable insights into data management in vocational education and training from an international perspective and show how data is used to address challenges such as social inequality, skills gaps, and difficult transitions from training to employment. The topics cover the entire spectrum from the development of data and monitoring systems to the data-based implementation of vocational education and training policy. The contributions also show how data is used to improve education systems in each country's own national context and according to its own priorities. Whether the focus is on long-term research, open data platforms, or innovative policies, the contributions underscore the importance of international cooperation and the exchange of good practices for the further development of vocational education and training.

Against the backdrop of a growing need for high-quality and comparable data and the increasing role of artificial intelligence, this publication emphasizes the importance of cross-border cooperation. Many countries face similar challenges. The solutions presented here show how data-based approaches can be adapted to national and local needs. The collection not only highlights challenges but also proposes practical solutions, thus underscoring the opportunities that global exchange offers for the further development of vocational education and training systems.

We are confident that this publication will provide a basis for new research approaches and stimulate further cooperation. It encourages countries to share their expertise and experiences in the field of data management. By using high-quality data, we can develop even more effective, equitable, and resilient vocational education and training systems that equip people with the right skills and qualifications for the global labour market.

This anthology was planned by the International Office for Vocational Education and Training (GOVET) at the BIBB and published by the BIBB's Publications Management.

I would like to thank everyone involved for their valuable work and invite readers to immerse themselves in the world of data management in vocational education and training.

Prof. Dr. Friedrich Hubert Esser
President of the Federal Institute for Vocational Education and Training
from May 2011 to June 2026

Ralf Hermann, Hannelore Kress, and Julia Olesen

Introduction: Transforming Vocational Education and Training through Artificial Intelligence, Data, and Global Exchange – A Changing Landscape for Vocational Education

The landscape of Vocational Education and Training (VET)[1] is being reshaped by powerful dynamics of change. Digitisation, demographic shifts, and accelerated labour market transformation are driving the need for more responsive, inclusive, and future-oriented training systems. Within this context, the role of data and artificial intelligence (AI) has become central – not only as technical tools but as strategic levers for system reform, quality assurance and equitable access to skills development. However, these transformations do not occur in isolation. They are embedded in broader processes of international cooperation, global vocational networks, and exchange of good practices. Recognising the diversity of VET systems across the globe, this volume draws on the experiences of 16 countries through 32 contributions, offering a unique platform for mutual learning, policy reflection, and shared innovation.

Evidence-Based Policy and the Strategic Role of Data

Over the past two decades, data have become indispensable in shaping educational and labour market policy.[2] No longer confined to administrative reporting, data are now integral to evidence-based policymaking, enabling governments and institutions to align training provision with real-time labour market needs, anticipate emerging skills trends, and monitor systemic performance. This shift is part of a broader movement in which performance metrics and analytical tools guide strategic decisions and institutional learning.

At the heart of this development is the growing capacity to collect, analyse, and interpret complex datasets. Integrated management information systems, skills anticipation mechanisms, and tracer studies are increasingly used to support national and regional VET strategies. These data infrastructures are not only technical systems but also institutional

1 In this publication, the terms Vocational Education and Training (VET) and Technical and Vocational Education and Training (TVET) are used synonymously and by the authors according to the prevalence of the term in their respective context, country or region.

2 We used Artificial Intelligence concerning structure, OpenAI, ChatGPT (Version 5.0, September 2025) as well as DeepL translation for quality assurance.

commitments – requiring legal frameworks, cross-sectoral coordination, and investment in human and organisational capacities.

The Transformative Potential of Artificial Intelligence

Artificial intelligence is rapidly transforming how we learn, teach, assess, and manage education systems. In VET, AI technologies are enabling personalised learning pathways, intelligent tutoring systems, and real-time performance analytics. They are reshaping how competencies are assessed and how certificates are issued and verified, supporting greater efficiency and reliability of qualification frameworks.

Moreover, AI plays a growing role in labour market forecasting, helping VET providers and policymakers to anticipate demands for skills and occupations. In doing so, it facilitates dynamic curriculum development, tailored career guidance, and a better alignment between training and employment opportunities. These developments, however, must be governed responsibly, with attention to data ethics, inclusivity, and the risk of digital exclusion.

Global Networks and the Exchange of Practices

The transformation of VET systems is not solely a national endeavour – it is deeply informed by international collaboration and peer learning. This compendium illustrates the richness of such exchange, with contributions from Africa, Asia, Europe, and Latin America highlighting diverse approaches, innovations, and challenges. Countries share not only successes but also unresolved challenges and open questions, fostering an honest and productive dialogue about the improvement of the system.

Global vocational networks and bilateral cooperation provide the framework for these exchanges. Through strategic partnerships, joint research, and capacity-building projects, countries learn from each other and adapt solutions to their own contexts. Whether through international organisations such as UNESCO and the ILO, or through regionally focused initiatives, these networks enable VET actors to co-develop benchmarks, methodologies, and mutual understanding.

The 32 articles in this volume underscore the value of such international engagement. They explore how reporting systems have been institutionalised, how data are turned into actionable policy, and how digital tools – including AI – are reshaping VET at the classroom and system levels. From case studies on national monitoring frameworks to reflections on ethics and innovation, the volume offers a broad overview of emerging global practices.

A Holistic Approach to Sustainable Transformation

Several cross-cutting insights emerge from the contributions. First, effective data use depends not only on technology but also on human and institutional capacities. This includes an institutionalised approach and a legal mandate for TVET reporting. Second, participatory approaches involving stakeholders at all levels improve data relevance and uptake. Third, while innovation is flourishing, the risk of digital divides and exclusion must be carefully managed. These findings suggest that systemic approaches – integrating governance, capacity building, and stakeholder engagement – are essential for sustainable progress.

In this sense, the exchange of practices across borders becomes a vital resource for navigating complexity. International cooperation not only enhances knowledge transfer but also strengthens solidarity in addressing global challenges such as youth unemployment, skills mismatch, and educational inequality. As VET continues to evolve in response to technological, economic, and social shifts, the integration of AI and data-driven governance will remain central. But just as important are the networks of cooperation, shared learning, and mutual respect that allow countries to support each other in this journey. The contributions gathered here offer both inspiration and practical tools for policymakers, educators, researchers, and international partners committed to building robust, flexible VET systems in times of global challenges.

Chapter 1: Establishing National TVET Reporting Structures and Monitoring

Bettina Milde

Data Reporting in Germany – Emergence, Relevance and Content

This interview with Bettina Milde from BIBB outlines the origins, legal basis, and development of VET reporting in Germany. It explains the dual structure of the Vocational Education and Training Report and the BIBB Data Report, their methodological foundations, and the political relevance of evidence-based data. Milde highlights the role of indicators, long-term data series, and cross-institutional collaboration. The interview also reflects on challenges such as data accessibility, data availability and digital publishing.

Ms. Milde, you deal with VET reporting, and your department at the Federal Institute for Vocational Education and Training (BIBB) is responsible for the annual BIBB Data Report[1]. What information does the Data Report contain?

Ms. Milde: The Data Report contains comprehensive information and analyses on initial and continuing vocational education and training in Germany.[2] It also provides an overview of federal and state programmes to promote vocational education and training and information on international indicators and benchmarks. With its annually changing main topic, current issues relevant to education policy are addressed. There is a series of standard indicators that are reported on annually. Long time series are available here. In addition, the Data Report also includes in-depth analyses based on our own primary surveys and secondary statistical analyses.

In Division 1.1, we are in charge of compiling the Data Report. I myself was seconded to the Federal Ministry of Education and Research for several years, where I was also responsible for the Vocational Training Report. So both reports are very important to me.

Why does this extensive data compendium exist in Germany?

In Germany, there is a legal mandate for reporting on vocational education and training. According to Section 86 of the Vocational Training Act (BBiG), the Federal Ministry of Ed-

1 See also here for latest volume in German: URL: **www.bibb.de/datenreport** (Retrieved on 19.05.2025); see here for English translation of the BIBB Data Report 2021: URL: **https://www.bibb.de/datenreport/en/datenreport_2021.php** (Retrieved on 19.05.2025).

2 Translation with DeepL, 19.05.2025.

ucation and Research (BMBF[3]) must constantly monitor developments in vocational training and submit a report (the Vocational Training Report) to the Federal Government by May 15 each year. The report must describe the status and expected further development of vocational education and training. If it appears that the provision of a regionally and sectorally balanced supply of training places is jeopardised, proposals for remedial action are to be included in the report. The BIBB has the task of participating in the preparation of the Vocational Education and Training Report (§ 90 BBiG). The first Vocational Education and Training Report was published in 1977, almost 50 years ago. The legal basis at that time was the Act on the Promotion of the Supply of Training Places in Vocational Training (Training Place Promotion Act – APIFG).

The BIBB Data Report has existed since 2009 and is based on a recommendation made by the BIBB Board in 2007. The Board is made up of equal numbers of representatives from the Federal Government, the federal states and employers' and employees' organisations. It is a statutory advisory body to the Federal Government on fundamental issues relating to vocational education and training. This also includes drafting an opinion on the Vocational Education and Training Report. The Main Committee had recommended reforming the Vocational Training Report and restructuring it as a whole. I think that streamlining considerations also played a role here at the time, as the Vocational Training Reports had grown to almost 400 pages over the course of time – that's quite a lot of pages for an advisory document for a committee. As a result, we now have the Federal Government's Vocational Education and Training Report with the most important data and trends and their political evaluation. We are continuing to work on this. The Data Report on the BIBB Vocational Education and Training Report contains in-depth analyses and long-time series. It not only provides the data basis for the Vocational Education and Training Report but also contains far more information and has developed into an important source of information on vocational education and training in Germany since its first publication.

The Vocational Education and Training Report has been around since 1977, so for almost fifty years. How has the topic of vocational education and training reporting developed over the decades?

As mentioned at the beginning, the Vocational Training Report goes back to the 1976 Training Place Promotion Act. The central political objective of the Act was to create and secure a sufficient supply of training places in view of the large number of school leavers in West Germany. To this end, transparency was to be created and this was to be achieved with the Vocational Training Report. The BIBB survey of newly concluded training contracts as of 30 September was created as a new instrument. This data and the data from the training market statistics of the Federal Employment Agency (BA) on unfilled vocational training places and applicants still seeking training were to be used to report on the development

3 At the time of the interview, the BMBF was the ministry with the legal responsibility in VET. With a new government that was formed in May 2025, the decision was taken to shift the area of education towards the Federal Ministry for Education, Family Affairs, Senior Citizens, Women and Youth (BMBFSFJ).

of supply and demand on the training market. At the time, the law also provided for a vocational training levy on the part of companies (APlFG) if the number of training places offered by the economy did not exceed the demand from young people by at least 12.5 percent. However, the levy was highly controversial among employers and was never imposed. The APlFG was declared null and void by the Federal Constitutional Court in 1976 due to a formal error in the legislative process. If you are interested in the historical context: this can be found in the chronicle BIBB/40 Years of the Federal Institute for Vocational Education and Training[4], which the BIBB published to mark its 40th anniversary in 2010.

The beginnings of vocational training reporting were well before my time. However, I was still aware of how intensively the official training market balance was discussed and also questioned in the past. There was particular criticism of the definition of demand at the time as the sum of newly concluded training contracts (see also the BIBB survey as of 30 September[5]) and the number of unplaced applicants registered with the BA (see also the BA statistics[6]). In the meantime, the situation has eased comparatively. However, it took extensive research, particularly by the BIBB, to be able to depict the training place market more realistically. There is now a consensus that the number of young people seeking training is not fully represented by the traditional definition of demand. The Vocational Education and Training Report and the Data Report therefore also show the expanded demand, which includes not only the number of newly concluded training contracts and unplaced applicants but also the number of applicants who had entered an alternative destination but were still seeking a training place.

With the separation into the Vocational Education and Training Report and the Data Report, a stronger focus was placed on indicator-based reporting. Indicators were also used in earlier VET reports (e.g. the supply-demand ratio). However, the indicators were significantly further developed and refined in the course of the reorganisation. With regard to further development: a good example of this is the integrated reporting on training (iABE), which was set up in 2009. With iABE, it has been possible to develop a system of indicators that are now recognised and established in education reporting, which provide a systematic overview of developments in (vocational) education and training in the various education sectors (vocational training, transition area, acquisition of higher education entrance qualifications and higher education studies) in Germany. This broadening of the perspective in reporting in recent years is accompanied by clear added value. This also applies to the expansion of the database. The Data Report now utilises a wide range of data from various sources. In addition to official and process data (e.g. vocational education and training statistics from the Federal and States' Statistical Offices, BA training market statistics) and data from the BIBB's own surveys (e.g. the BIBB survey as of 30 September, BIBB Qualification Panel), data from surveys that the BIBB conducts jointly with other institutions (BA/BIBB applicant surveys (new: BA-BIBB-IAB applicant study), BIBB/BAuA employment survey, wbmonitor) or external data sources (e.g. microcensus, IAB establishment panel)

4 See also here (in German): **https://www.bibb.de/dienst/publikationen/de/6245** (Retrieved on 19.05.2025).

5 See also here (in German): **www.bibb.de/naa309** (Retrieved on 19.05.2025).

6 See also (in German): **https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Fachstatistiken/Ausbildungsmarkt/Aktuelle-Eckwerte-Nav.htm** (Retrieved on 19.05.2025).

contribute to the report. Only in this way is it possible to comprehensively depict the relevant developments in vocational education and training.

As early as 1977, the Vocational Education and Training Report was already subject to a high standard when it was described as the "main book of vocational education and training", which was intended to provide comprehensive information to those directly involved in vocational education and training and the public. We have realised this goal ever since, and I am grateful to everyone involved.

How does the Data Report specifically contribute to overcoming the challenges of vocational education and training?

In my opinion, the Data Report and the VET report must be seen together. The first thing that applies to both is that they visualise developments and also highlight the need for action, which can and will be taken up by policymakers, but also by all other stakeholders in vocational education and training.

In this context, it is important to emphasise the various consultation and coordination processes involved in the creation of the Vocational Education and Training Report, in which the key stakeholders in vocational education and training are involved. The Vocational Education and Training Report is first discussed in the Vocational Education and Training Report Subcommittee and then in the BIBB Board. Employer and employee representatives as well as representatives of the Federal Government and the Länder are represented here. The Board then officially comments on the Vocational Education and Training Report. The BMBF also coordinates the draft report with the other federal government departments. Although this is a relatively time-consuming process, the participation structures ensure the high information content of the report as well as its acceptance, dissemination and transfer.

Although the Data Report itself is not discussed here, it is, of course, included as a data basis. In addition, the Vocational Education and Training Report contains a large number of references to the corresponding chapters of the Data Report, in which more in-depth analyses are provided. The scientific analyses in the Data Report can therefore also be accessed.

The Vocational Training Report is addressed directly at policymakers. By law, it must be submitted to the Federal Cabinet by 15 May. Once it has been referred to the Cabinet, the Bundesrat (i.e. the federal states) and the Bundestag are informed. As a rule, the Bundestag then debates the Vocational Education and Training Report and the situation of vocational education and training in Germany in general. The debate also deals with motions submitted by the parliamentary groups/parties with political demands. The Vocational Education and Training Report and the motions are then referred to the Bundestag committees. They have the task of preparing plenary resolutions and discussing the content of possible draft legislation. The Committee on Education, Research and Technology Assessment takes the lead. The committee votes on the acceptance/rejection of motions on the Vocational Training Report. The result of the discussion in the committees then flows back into the Bundestag. In this respect, the data is used directly to shape policy at the federal level.

In addition, the results reported in the Vocational Education and Training Report and the Data Report also provide a basis for discussions in the Alliance for Initial and Further Training and other bodies. The BIBB also regularly receives requests for presentations on this topic. We are pleased to see that our findings are utilised accordingly.

How is the Data Report used in politics, science and practice?

Very few people will read the entire Data Report. But you can't expect them to because it is far too comprehensive for that. Rather, they will use it selectively, depending on their questions and areas of interest. The Data Report not only provides more comprehensive information than the Vocational Training Report on the various topics, it also contains more explanations of the data and methodological notes on the calculation of the indicators, which is, of course, also of interest to readers from the scientific community. Experience has shown that the long-time series are also of interest here. The fact that the authors are always named means that the Data Report can also help readers to find the right contact person to clarify any further questions they may have.

Please tell us how the annual Data Report is produced at the BIBB.

First, the outline is created. The internal and external authors can contribute their suggestions here. Many chapters have now proved their worth and are updated annually. The outline is agreed at the end of May with the editorial group, which consists of institute and department heads, members of the editorial team and the publications department as well as a representative of the BMBF.

The general submission deadline for contributions is the end of September. This deadline should only be exceeded in exceptional cases, for example, if the required data is not available until a later date. Unfortunately, this is the case for many of the data sources used in the Data Report, meaning that the majority of contributions are not available until the end of the year or even the first quarter of the new year.

The contributions are submitted to the editorial team in my department via the official channels (work area management, department management) and edited. If necessary, suggestions for changes are communicated with the responsible authors and implemented. The contributions are then sent to the editorial team (Publications and Scientific Information Services Unit at the BIBB). In January, the editorial group makes recommendations for revision, if necessary, which are taken into account in the drafts. The draft chapters are then sent to the publisher for typesetting.

The Data Report is always published at the same time as the Vocational Education and Training Report in May.

The Vocational Education and Training Report is published on the BMBF website at the same time as it is referred to the Cabinet. As a rule, the BMBF then also issues a press release. At the same time, the Data Report (as a preliminary version) is published on the BIBB website. We also issue a press release.

The printed versions of the Data Report and the Vocational Training Report will then be available in late summer.

Who are the authors contributing to the Data Report?

The authors are primarily employees from the various BIBB departments. Unlike the Federal Government's Vocational Education and Training Report, the Data Report contributions are published as author contributions, i.e. the authors are named. Most of the contributions come from Department 1 "Vocational Education and Training Research and Monitoring" (also for reasons of responsibility). However, the other BIBB departments are also involved, e.g. with regular contributions on current developments in the regulatory business, on the promotion of vocational education and training and on vocational education and training in international comparison. For this reason, the BIBB's institute and department heads are also represented in the Data Report's advisory editorial group (see above).

In addition, the Data Report also includes contributions from people from other institutions. This makes it possible to include a broader spectrum of information and perspectives in the report. Every two years, for example, the Institute for Employment Research (IAB) reports on the results of its establishment panel. The IAB Establishment Panel has been in existence for over 30 years. It currently includes data from around 16,000 companies. This naturally makes it an interesting source for the Data Report. The German Institute for Adult Education (DIE) is also responsible for articles in the Data Report, in this case specifically on the subject of continuing education. For several years now, authors from the German Centre for Higher Education Research and Science Studies (DZHW) have been writing a chapter on the post-school careers of people with higher education entrance qualifications. The data source here is the DZHW Student Life Cycle Panel. The DZHW analyses are a good example of a chapter that has recently been added externally in order to address a current educational policy issue – the attractiveness of dual vocational training from the perspective of those with higher education entrance qualifications.

I think these examples show quite well what is important to us. Our aim is to depict the breadth of vocational education and training in the Data Report and to provide information that is relevant to the current education policy debate. The focus is on indicator-based long-term observation. However, exceptions are, of course, also possible when it comes to focussing on specific issues, e.g. in the annually changing topics.

How are the annual topics of interest determined?

The annual topics of interest are discussed and determined in the editorial group of the Data Report and also agreed with the BMBF. Prior to this, proposals are collected that address current educational policy or socially relevant topics. Previous topics of interest were, for example, "Permeability between vocational education and training and academic higher education" (2011), "Vocational orientation" (2018), "Higher-qualification vocational education and training – paths to career advancement" (2021) and "Innovations in vocational education and training through programmes" (2023). The Data Report 2025 focuses on the topic of “Immigration Society” and the current Data Report 2026 focuses on the topic of “Artificial Intelligence”.

In your experience, what are the critical success factors for a good Data Report?

Of course, a good database is a key success factor for a good Data Report. Data quality plays an important role, as does the transparency of the data used. A Data Report should therefore always include methodological information on the data sources (e.g. the survey method or sample sizes). With regard to the indicators, it is important that these are science-based and also transparent. Calculations should be comprehensible. All of these points ensure trust and therefore acceptance. Timeliness is also important. A Data Report should be updated regularly to reflect the latest data and developments. It should not only present data but also contextualise and interpret the developments shown by the data. It is important that it is written in clear and understandable language, so that it is equally comprehensible for all readers. An appealing visualisation of the data is helpful. A Data Report should also be easily accessible (e.g. by making it available on the internet).

What future developments do you see for the Data Report? Will it continue to exist as an instrument over the coming decades?

I very much hope so. The Data Report is a very good and comprehensive source of information on vocational education and training. Not only for those involved in vocational education and training and for politicians but also for the general public. In my opinion, reliable sources of information are becoming increasingly important, especially in these increasingly difficult times, also in order to be able to distinguish facts from opinions or even disinformation. So, I wouldn’t want to call the product into question under any circumstances. However, I could imagine that the way we publish the Data Report will change in future. The Data Report is already being published online, but the entire publication process is still focussed on print production. The question here is how long we still consider this to be appropriate and whether we should break new ground and switch to a purely online format, perhaps with provision dates during the year depending on data availability.

Tran Van Khoi, Phung Le Khanh, and Nguyen Quang Hung

Vietnam Vocational Education and Training Report: A Development Journey for National TVET Reform

This article provides an overview of the development of the Vietnam Vocational Education and Training Report (Vietnam TVET Report) since its inception in 2011. Over the years, the report has served as a critical tool for consolidating, analyzing, and providing information that reflects the status and trends of the Technical and Vocational Education and Training (TVET) system in Vietnam. It is a valuable reference document that presents a comprehensive, objective, and up-to-date picture of the TVET landscape, supporting policymakers, TVET institutes, businesses, researchers, and domestic and international stakeholders. The article also highlights key limitations and challenges in the report's development process, followed by recommendations to improve its quality and utility moving forward.

1 The development journey of the Vietnam TVET Report (2011 – present)

To provide comprehensive, objective, and up-to-date information on the status and development trends of Vietnam's TVET system for policymakers, TVET institutes, enterprises, workers, and both domestic and international organisations and individuals, the Vietnam TVET Report has been developed and published annually since 2011. Throughout its formation and development, the report has become a critical tool supporting state management and policymaking in the TVET sector, and bridging TVET with the labour market.

With the endorsement of the leadership of the former Directorate of Vocational Education and Training – DVET (now the Department of Vocational Education and Training and Continuing Education under the Ministry of Education and Training - MOET), the Vietnam National Institute of Vocational Education and Training (NIVT) (now the Research Center of Vocational Education and Training under the Vietnam National Institute of Educational Sciences, MOET) was officially assigned the responsibility for compiling the annual Vietnam TVET Report. To date, 11 reports have been officially published, covering the years 2011, 2012–2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, and 2022. The reports are available in both Vietnamese and English to serve domestic users as well as international experts and institutions interested in Vietnam's TVET system. Initially consisting of 11 chapters, the Report has been restructured into 9 chapters since 2012 to present a holistic overview of the system, its key strengths and limitations, and to propose relevant policy recommendations for enhancing the quality and effectiveness of the TVET system.

From the outset, the development of the Vietnam TVET Report has benefited from the active involvement of DVET units, TVET institutes, enterprises, and national and international experts through workshops, forums, academic roundtables, and rapid assessments. These contributions have enriched the Report with valuable information and feedback, thereby improving both the analytical depth and the quality of its policy recommendations.

In particular, technical support from the German Federal Institute for Vocational Education and Training (BIBB) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has played a vital role in aligning the Report's methodology with international standards. This support has enabled Vietnam to gradually build a high-quality and consistent annual TVET reporting system. BIBB and GIZ have collaborated with NIVT to organise capacity-building activities for the report development team and have supported consultation workshops to gather stakeholder feedback for improving report quality. Thanks to this effective collaboration, the report has been continuously improved in both content and methodology, reinforcing its role as a key reference in policymaking processes to develop a demand-oriented TVET system that aligns with both domestic labour market needs and global trends.

With technical and professional support from BIBB and GIZ, the report is developed on the basis of systematising comprehensive indicators, reflecting the performance of the TVET sector across nine key areas: (1) TVET policies; (2) TVET for labour market; (3) Network of TVET institutes; (4) TVET admissions and graduations; (5) TVET teachers and management staff; (6) Development of occupational skills standards; (7) Quality assurance and accreditation; (8) Finance for TVET; and (9) Cooperation with businesses.

In addition to presenting quantitative data, the Vietnam TVET Report also integrates qualitative analysis and policy recommendations. It draws from officially published secondary data sources, including those from the General Statistics Office, the former Ministry of Labour – Invalids and Social Affairs/DVET, and relevant thematic surveys and reports. All sources and methodologies are clearly cited to ensure transparency and objectivity. A noteworthy feature of the report is its alignment with international indicator frameworks, including the Sustainable Development Goals (SDGs) and the European Quality Assurance in Vocational Education and Training (EQAVET) framework. This enhances the international comparability of Vietnam's TVET system while improving the transparency and effectiveness of its monitoring and evaluation processes.

2 The report's role in Vietnam's TVET ecosystem

The Vietnam TVET Report serves as an effective tool for a wide range of users within Vietnam's TVET ecosystem for different objectives. Over more than a decade of implementation, the report has affirmed its significance and utility, being widely used by state management agencies, TVET institutes, enterprises, and domestic and international stakeholders.

2.1 Providing evidence for policymaking in the TVET sector

For policymakers and state management bodies, the Vietnam TVET Report functions as an official and reliable source of information, supporting regular monitoring and comprehensive evaluation of the system's performance. With its annual updates and systematic coverage of nine key areas – from policy formulation, training quality to enterprise cooperation – the report enables the identification of emerging trends and areas requiring adjustment. It serves as a critical evidence base for developing medium- and long-term TVET strategies, facilitating efficient resource allocation and ensuring that policies and programmes are aligned with labour market demands and broader development trends.

Box 1: Reskilling and Upskilling Needs in Response to the Fourth Industrial Revolution (4IR)

"47.1 percent of enterprises believe that workers need to be trained in new occupations and vocational skills at the college and intermediate levels.
46.6 percent of enterprises consider that the appropriate training duration should be less than 12 months.

Unskilled and untrained workers still make up a large proportion – 55 percent – of the total workforce across 700 surveyed enterprises. In contrast, those who have received vocational training of less than 3 months, or at primary, intermediate, or college levels, account for only 24.7 percent.

Meanwhile, 25.9 percent of workers are currently in positions directly affected by 4IR, primarily in fields such as industrial electricity, computer programming, industrial electronics, automation, multimedia design, and others."

Source: Vietnam National Institute of Vocational Education and Training 2022, p. 27

Box 1 illustrates how the Vietnam TVET Report can provide critical evidence for policymaking in the TVET sector. The survey results presented in the report reflect enterprise demand for reskilling and the development of new skills in the context of 4IR. These findings support the design of policies that promote short-term training, prioritise strategic occupations, and allocate resources in alignment with technological transformation under the new development context.

2.2 Supporting the evaluation and improvement of TVET institutes' performance

For TVET institutes, the Vietnam TVET Report serves as a reliable and valuable reference for evaluating their performance in comparison with sector-wide benchmarks. Based on specific indicators such as enrollment and graduation rates, lecturer capacity, and levels of enterprise cooperation, the institutes can assess their relative standing and make informed adjustments to training programs, teaching methods, and internal quality assurance systems.

At the same time, the report provides timely insights into labour market trends and shifting skill demands, enabling institutes to proactively strengthen linkages with industry, update curricula, and orient their improvement initiatives accordingly.

2.3 Providing information for enterprises and employers in workforce planning

Enterprises and employers are among the key beneficiaries of the Vietnam TVET Report, as it offers practical information on training quality, occupational skills, and workforce readiness for the labour market. The report also reflects shifts in labour demand trends, thereby supporting businesses in developing recruitment strategies, reskilling plans, or tailored training partnerships.

Additionally, the report serves as a valuable source of information for foreign enterprises exploring the Vietnamese market, enabling them to assess the quality of the technical workforce and make informed decisions regarding investment, recruitment, or training collaboration.

2.4 Providing career guidance information for students, parents, and the community

The Vietnam TVET Report also plays a vital role in informing students, parents, and the community by providing information on employment rate, employer satisfaction, and emerging career trends. This contributes to more informed decision-making in selecting fields of study and career paths, thereby improving graduates' adaptability and employability. At the same time, it enhances public awareness of the role of TVET in personal and national development.

By promoting a positive image of the TVET system, the report gradually helps shift social perceptions toward TVET, encouraging vocational training as a practical and sustainable choice for learners.

2.5 Serving as a reference source for researchers and international organizations

For international organizations, development partners and researchers, the Vietnam report is a valuable bilingual reference publication. It offers transparent presentation, objective data, and analysis grounded in internationally recognised indicator frameworks such as the SDGs and EQAVET. As a result, it has been used to inform the design of technical cooperation programmes, investment appraisals, and in-depth studies in the field of skills development and TVET. Several international organisations, including GIZ, International Labour Organization (ILO), and Korea International Cooperation Agency (KOICA), have relied on the report's data to develop cooperation plans and monitor the progress of TVET reforms in Vietnam.

3 Limitations and challenges in the development of the Vietnam TVET Report

Despite its positive contributions in informing stakeholders, the development of the Vietnam TVET Report still faces several limitations.

First, critical indicators such as post-training employment rates, income levels, and skill relevance by occupation and training level have not been consistently collected or regularly updated. The report relies heavily on secondary data, which often lacks disaggregation by industry and qualification levels (elementary, intermediate and college), thus affecting the timeliness and granularity of the information presented.

Second, the voices of enterprises, students, alumni, and teachers regarding training quality and labour market relevance have not been systematically captured. The absence of regular surveys, in-depth interviews, or sociological studies limits the depth of analysis and hinders multi-stakeholder perspectives. Consequently, the report remains primarily descriptive and data-driven, without sufficiently exploring underlying factors or stakeholder insights.

Third, limited financial resources present a major constraint to conducting comprehensive consultations, such as thematic workshops, stakeholder dialogues, or field-based assessments. Moreover, the report lacks an institutionalised mechanism for monitoring its usage and evaluating its policy impact on a regular basis.

Fourth, the report's content is still largely descriptive, with insufficient analysis of future labour market trends, emerging occupations, or skills affected by 4IR, digital or green transformation, or green transition. This limits its capacity to provide forward-looking policy insights and strategic orientation.

Finally, communication and dissemination of the report remain limited, reducing its outreach to broader user groups. At the same time, the technical capacity of the report development team requires further strengthening. Many experienced experts have been reassigned, while the increasing complexity of analysis calls for new skills, particularly in working with emerging data sources such as big data.

4 Key recommendations for enhancing the quality and impact of the Vietnam TVET Report

To improve the quality and practical utilisation of the Vietnam TVET Report, several coordinated actions are recommended.

First, it is essential to strengthen the national TVET information system to ensure regular, accurate, and comprehensive data collection, updating, and sharing. This need is particularly pressing in the context of ongoing efforts by Vietnam's Party and Government to streamline the state administrative apparatus. Accordingly, NIVT – formerly under DVET of the Ministry of Labour – Invalids and Social Affairs – has been restructured into the Research Center of Vocational Education and Training under the Vietnam National Institute of Educational Sciences, MOET. As state management functions related to labour and employment have been transferred to the Ministry of Home Affairs, maintaining a robust input data system that covers both labor supply and demand requires inter-ministerial co-ordination. This coordination is essential to ensure that the report continues to serve as a comprehensive source of information that reflects the connection between the TVET system and the labour market.

Second, it is important to conduct regular surveys and interviews with enterprises, students, alumni, and teachers to gather information on training quality, relevance to labour market needs, and skill gaps. The results of these surveys would provide a more realistic picture of the challenges facing the Vietnam TVET system. In-depth consultation activities – such as surveys, workshops, and policy dialogues with the participation of experts, TVET institutes, enterprises, and other stakeholders – should also be held on a regular basis to improve the content, structure, and practical utilisation of the report.

Third, organising public dissemination events for the Vietnam TVET Report – with the participation of enterprises, policymakers, and researchers – is an important channel for increasing its impact and application in practice. At the same time, the development of digital versions, policy briefs, or extractable data sets will enable the report to better serve the needs of different user groups.

Fourth, the technical capacity of the report development team should be strengthened through targeted training and international knowledge exchange.

Fifth, annual thematic studies should be conducted to address emerging and high-priority issues in the TVET sector. Each year, one or more key topics could be selected – such as digital transformation, enterprise-linked training, or skills for the green and digital economy. These studies would enrich the analytical depth of the report and enhance the relevance and attractiveness of its content.

In conclusion, after more than a decade of development, the Vietnam TVET Report has become more than just a tool for consolidating and presenting the status and development trends of Vietnam's TVET system. It has established itself as an important evidence-based reference for policy formulation, training improvement, and labour market alignment. As Vietnam's TVET system is undergoing transformation to meet new reform demands, the report must continue to evolve in terms of quality, analytical depth, and practical utility to truly serve as a strategic instrument for driving national TVET reform forward.

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Julia Olesen and Hannelore Kress

Introduction of a National TVET Report in Ghana – Experiences and Methodology within the Bilateral Cooperation between Ghana and Germany

The interview with Julia Olesen provides insight into the development and implementation of the national TVET report in Ghana within the framework of bilateral cooperation with Germany. It highlights the starting point of a fragmented vocational education and training system, the role of the 2019 Memorandum of Understanding, and the methodological challenges involved in data collection. GOVET provided comprehensive support to the Commission for TVET in the form of advice, quality assurance, and training. The report now serves as a central source of information for policymakers and institutions and contributes to greater transparency and governance in the Ghanaian vocational education and training system. In the future, reporting will be further institutionalised and strategically expanded.

Introduction

The interview highlights the development and implementation of a national vocational training report (TVET report) in Ghana.[1] This report was initiated as part of a bilateral cooperation between Ghana and Germany. The Central Office for International Cooperation in Vocational Education and Training (GOVET) has supported the process continuously since 2020. Over a period of several years, regular virtual working meetings took place between GOVET and the Commission for TVET (CTVET). In these meetings, the Ghanaian partners developed data collection tools with methodological and content-related support from GOVET, conducted their own surveys, and prepared the results in a structured manner. More than 20 CTVET employees participated in this work – as authors and by contributing to data collection and analysis. For the first report, data was collected from 85 vocational training institutions; in the second round of reporting, the number of institutions contacted rose to over 230. The interview between the two GOVET colleagues Dr. Hannelore Kress, team leader for bilateral cooperation, and Julia Olesen, project manager for Ghana, looks back on developments to date and highlights the methodological approach in particular.

1 This article was reviewed and translated with the assistance of OpenAI's ChatGPT (5.0) and DeepL on 16 July 2025.

H. Kress: How did the idea of developing a national TVET report for Ghana come about?

J. Olesen: The idea of developing a national vocational training report for Ghana was put forward by the then Council for Technical and Vocational Education and Training (COTVET), which was later transferred to the Commission for TVET (CTVET). During the first bilateral exchange meetings in 2018 between GOVET and the Federal Ministry of Education and Research (BMBF), COTVET signalled that there were major gaps in knowledge regarding basic figures and data on the vocational training system. At that time, the vocational education and training sector in Ghana was still highly fragmented: in addition to the Ministry of Education, there were 18 other ministries, each of which maintained its own vocational training institutions, developed curricula, and implemented programmes. This decentralisation led to a confusing situation and made it very difficult to access reliable figures, data and facts about the vocational education and training system.[2] COTVET wanted to see greater transparency in order to enable more targeted policies. Our Ghanaian partners repeatedly described to us the challenge of obtaining even basic information about the national technical and vocational education and training (TVET) system. This problem led to the priority being set of establishing a joint reporting system for vocational education and training. The aim was to improve knowledge of the system, create transparency, and enable a data-based foundation for political and institutional decisions. A national TVET report was agreed on as the central product. The first report was published in 2022, the second in 2024, and work is currently underway on the third vocational training report, which is likely to be published in early 2026.[3]

H. Kress: What role does the 2019 "Joint Declaration of Intent" play in vocational training cooperation, and what binding commitments does it entail?

J. Olesen: The Joint Declaration of Intent (JDoI), signed in 2019 between the Ghanaian and German ministries of education, was a key milestone for structured cooperation in the field of vocational education and training. This formal document not only created the bilateral framework for cooperation but also laid the foundation for activities between the ministries and subsequent organisations, in particular between CTVET, GOVET and the BIBB, the Federal Institute for Vocational Education and Training, to be implemented in a legally secure manner. Such formal agreements are of central importance in internation-

2 For more information on the vocational training system in Ghana (in German): Olesen/Krichewsky-Wegener 2025. International Handbook of Vocational Education and Training (IHBB): Ghana. Federal Institute for Vocational Education and Training. Available at: **https://www.bibb.de/dienst/publikationen/de/20501** (Retrieved on 12.08.2025).

3 Ghana's first vocational training report is available at this link: **https://ctvet.gov.gh/wp-content/uploads/2022/09/GHANA-TVET-REPORT-2021SIGNED.pdf** (Retrieved on 12.08.2025).
Ghana's second vocational training report is available at this link: **https://ctvet.gov.gh/wp-content/uploads/2024/04/GHANA-TVET-REPORT-SECOND-EDITION-2023.pdf** (Retrieved on 12.08.2025).

al cooperation, as they give the partners on both sides certainty in their actions. At the same time, such a JDoI also lends political weight to the cooperation, which is particularly helpful in the context of education diplomacy and in interaction with various local stakeholders. The JDoI added the new focus area of vocational training reporting to the existing portfolio of German-Ghanaian education cooperation. While there were already numerous projects within the framework of development cooperation, including programmes run by the German Agency for International Cooperation (GIZ) and other actors, as well as the already existing cooperation in the field of research, such as the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) and the African Institute for Mathematical Sciences (AIMS), the establishment of a national vocational training report broke new ground. The report thus represented a real innovation in terms of content in the entire bilateral cooperation.

H. Kress: The first Data Report was published in 2022. What were the biggest challenges for CTVET and for the advisory services?

J. Olesen: The initial data collection involved a whole series of methodological and organisational challenges. First of all, the survey instruments had to be developed from scratch. This meant that we had to discuss fundamental questions with our colleagues at CTVET: what data do we actually need to paint a meaningful picture of the vocational training system? How do we need to query this data so that the institutions surveyed understand exactly what is meant? And how do we need to structure the survey periods and definitions so that the data reported back is comparable? All these questions had to be reflected in a digital survey tool that was logically structured and user-friendly – and this was by no means trivial. In addition, many of the training institutions surveyed were confronted with the requirement of systematically collecting certain data internally and then entering it into a digital tool for the first time. This was a completely new process for them. As the collaboration progressed, CTVET decided to use professional data collection software. The German Ministry of Education offered specific training courses on how to use this software in order to prepare employees optimally. It was important to develop appropriate indicators for the information we wanted to collect in advance. This is a complex process that is still ongoing, and new aspects are constantly emerging that need to be considered.

GOVET has played a central role in the entire methodological process since 2020 – both in terms of technical advice and in moderation and editorial quality assurance, e.g. the so-called pre-tests. The questionnaires and survey instruments developed were tested in advance with a selection of vocational training institutions. The results revealed ambiguous answer options, unclear questions and inconclusive results. This enabled us to make targeted improvements and further refine the survey instrument. Regular communication is a key factor for success. It demonstrates the seriousness of the partners because our colleagues also have other tasks to perform at the institute. We were involved at all stages and were thus able to monitor the progress of the report and discuss questions of content and methodology. I myself reviewed the survey instruments and provided feedback on the draft texts prepared by the various teams of authors. Where necessary, we were supported by colleagues from the BIBB, particularly in the areas of data research and data management. In addition to providing ongoing support, the BMBF also funded targeted training measures on data collection and analysis using digital tools, including the data analysis software SPSS (Statistical Package for the Social Sciences). The training courses were tailored precisely to the requirements of CTVET. Study visits to Germany were another important element of the cooperation. During these visits, members of the CTVET team had the opportunity to visit expert institutions in Germany and engage in intensive discussions on the topic of data reporting. We exchanged ideas with, among others, the Institute for Employment Research (IAB), the Leibniz Institute for Educational Trajectories and, of course, colleagues at the Federal Institute for Vocational Education and Training (BIBB).

H. Kress: Looking back, what were the biggest lessons learned in this bilateral process?

J. Olesen: The complexity of a vocational training report is often underestimated. It is a field in which many different stakeholders are involved – and these stakeholders handle data in very different ways. Some collect data systematically, others not at all. As a team, we had to break new ground, agree on common standards and develop and institutionalise processes for data exchange and data collection from scratch. However, reforms in the Ghanaian education system also helped to simplify individual steps in the process. While we still had to laboriously collect student numbers from various institutions such as the Ministry of Education, the Ghana Education Service, the National Vocational Training Institute (NVTI) and other organisations for the first report, we were able to draw on a central data source for the second report. Thanks to the harmonisation of the vocational training system, the Ghana TVET Service – a newly created central authority to manage all public TVET institutions – was able to provide the relevant data. This progress has greatly simplified the process and is a good example of how institutional reforms can have a positive impact on the data available and thus on reporting.

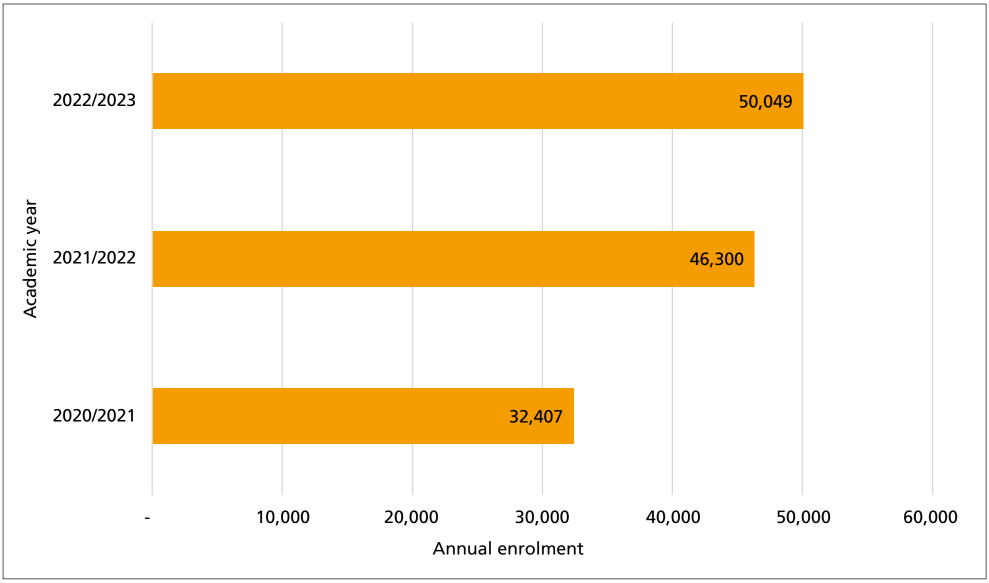
H. Kress: How has the cooperation with CTVET staff developed over the years?

J. Olesen: We have worked very closely together from the outset. The high level of staff continuity at CTVET is particularly noteworthy. Many of the colleagues who worked on the first report were also involved in the subsequent editions. This has enabled knowledge to be built up, passed on and embedded in the organisation for the long term. This institutional learning is an important factor in the success of the entire project. In return, our role at GOVET has also changed over time. Whereas at the beginning we provided initial advice and guidance, we now answer our partners’ technical questions in a targeted and needs-based manner.

H. Kress: What concrete results or changes have emerged from the TVET report for Ghana?

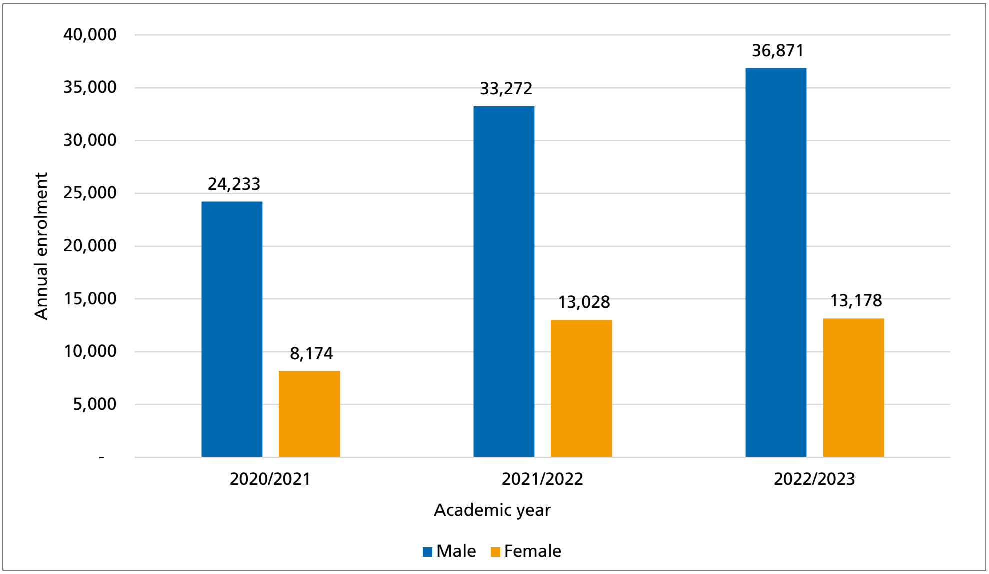
J. Olesen: The report has helped to highlight key developments in the Ghanaian vocational training system. For example, there has been a significant increase in the number of vocational school students over the last few years.

Figure 1: Annual enrolment in public pre-tertiary TVET institutions in Ghana



Source: CTVET 2023

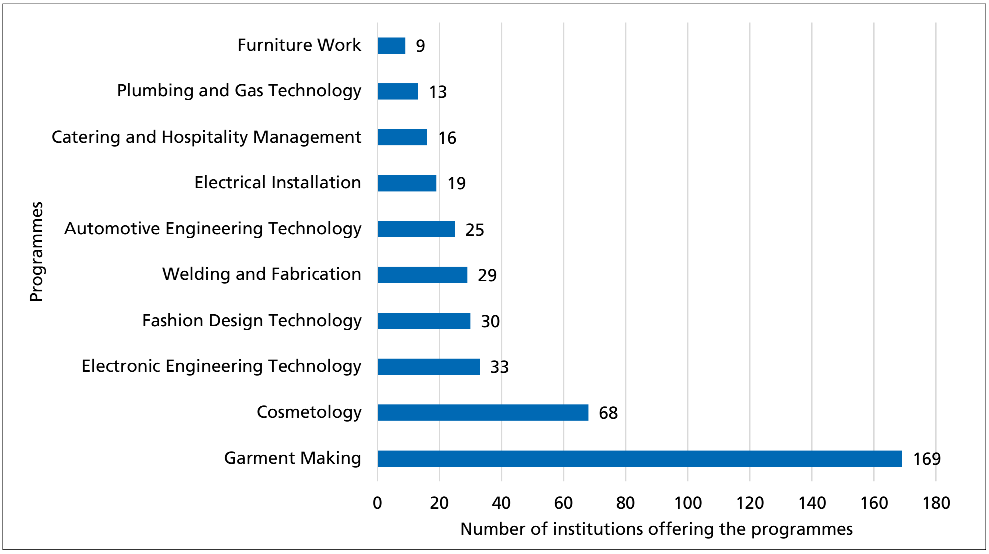
Figure 2: Annual enrolment in public pre-tertiary TVET institutions in Ghana per gender



Source: CTVET 2023

The report also shows that many vocational training institutions focus on subject areas that do not necessarily correspond to labour market demand.

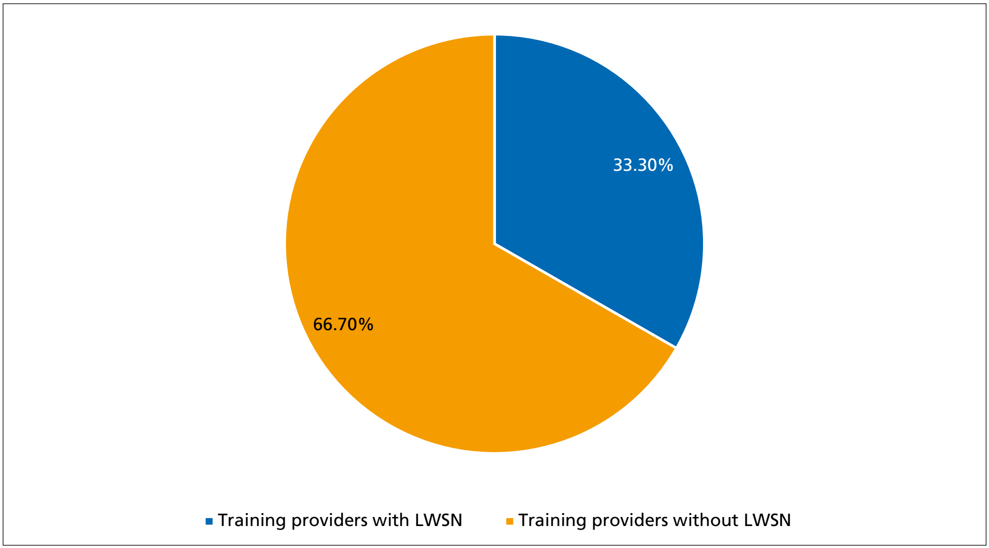
Figure 3: Accredited programmes among the 285 institutions surveyed (here: excerpt from the top 10 programmes)



Source: CTVET 2023

These findings are important for achieving a better match between supply and demand in vocational education and training. In addition, the report provides a structured data basis for policy decisions and the further development of the TVET strategy in Ghana. The first report also contains an overview of the reforms in vocational education and training in recent years. This information was not previously available in this form. The reports also address future issues such as inclusion, the participation of women and girls in vocational education and training, and sustainability, thereby bringing those topics back into the political and scientific discourse.

Figure 4: Training providers with learners with special needs (LWSN), based on a CTVET survey of 285 public and private institutions (in %)



Source: CTVET 2023

H. Kress: How are the vocational training reports used at the political or institutional level in Ghana?

J. Olesen: The vocational training report is actively used at both the political and institutional levels. It serves as a central source of information for basic data and facts on vocational training in Ghana. The report is publicly available. This step towards greater transparency was not a given, but it demonstrates the great trust and openness of our Ghanaian partners. This enables a fact-based and open exchange at the political level. At the same time, initiatives, reform measures, and successes are made visible. At the institutional level, the report serves as a catalyst for exchange between organisations, as a source of arguments for political decision-makers, and as a basis for concrete improvement measures in the education system.

H. Kress: Are there already plans to continue or further develop the reporting system?

J. Olesen: CTVET aims to further integrate reporting into the system and to further institutionalise it. The plan is to establish a permanent team within the organisational structure that will be responsible for the annual vocational training report and related activities. This continuity is particularly important as the vocational training report has been enshrined in law in CTVET's mandate since the reforms in 2020. At the same time, I see additional potential for future development. For example, the processes for exchanging data with other institutions, such as the Ghana TVET Service, which is responsible for managing all public vocational training institutions, could be further formalised and standardised. Closer cooperation with universities and research institutions would also be desirable in order to incorporate scientific findings more strongly into the report and thus to further increase its informative value.

H. Kress: What would you recommend to other countries that want to start a similar process?

J. Olesen: On the international level, we notice growing interest in data reporting at GOVET, and it is also a recurring topic during delegation visits.[4] In my view, it is particularly important that the decision to introduce a vocational training report must be supported at several levels – organisational, institutional, and political. In Ghana, there was broad consensus from the outset that this issue was a top priority. The Ministry of Education, the government and the leadership of CTVET were united in their support for the project; it requires not only resources but above all committed experts who are passionate about the issue and recognise its long-term benefits. I would also recommend that other countries view the establishment of a reporting system as a long-term process. It is by no means a short-term project that can be completed in a year and then run on a permanent basis. Rather, it requires perseverance and a willingness to continuously learn, adapt and improve.

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4 For further information, there are two presentations on data reporting and vocational training research, available at these links: **https://www.govet.international/en/207335.php** and **https://www.govet.international/en/207873.php** (both links retrieved on 12.08.2025).

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Robyn Schmidt and Stephan Kroll

The VET Entry Rate: An Indicator Providing Valuable Insights for Evidence-Based Decision-Making in Education Policy

The Vocational Education and Training (VET) Statistics of the Federal and State Statistical Offices is an annual comprehensive survey with data on all VET contracts under the Vocational Training Act (BBiG) or the Crafts Code (HwO) in Germany. Based on the VET Statistics, a wide range of indicators can be calculated to support evidence-based VET policy. This article focuses on one of these indicators – the VET Entry Rate. It represents the proportion of people who, over the course of their lives, begin a VET programme. The VET Entry Rate not only provides an overview of the quantitative significance of VET in Germany but also enables insights into the integrative performance of the VET system with regard to various demographic groups, such as people with different nationalities or genders.

1 Introduction

The Vocational Education and Training (VET) system, as part of the German education system, is closely linked to the employment system. Young people are expected to develop their professional competence through dual vocational training, thus securing their future employment. In order for this to succeed, the actors involved in VET must respond flexibly to new challenges and changing circumstances and environments. According to the Vocational Training Act in Germany, the Federal Ministry for Education, Family Affairs, Senior Citizens, Women and Youth (BMBFSFJ) is responsible for monitoring developments in VET. The ministry publishes the Vocational Education Report annually, which serves as a basis for political discussion and decision-making among VET stakeholders and the public (see BMBF 2025). Since 2009, this report has been complemented by the Data Report (on the Vocational Education Report) by the Federal Institute for Vocational Education and Training (BIBB), which includes a wealth of information and analyses regarding the state of and developments in vocational education and training (see BIBB 2024).

In order to learn from past developments, to accurately analyse the current situation of vocational education and training, and identify future challenges, a solid data foundation is required. The vocational education statistics of the Statistical Offices of the federal government and the states (referred to as vocational education statistics or the survey as of December 31, or simply VET Statistics) provide this foundation. The VET Statistics represent an annual comprehensive survey of data related to dual vocational training. It includes all training contracts in dual vocational occupations according to the Vocational Training

Act (BBiG)/Crafts and Trades Code (HwO) with an extensive catalogue of characteristics. Detailed professional, regional, and demographic differentiations can be made. Therefore, the data provide an excellent basis for analysing various aspects of VET, helping to highlight developments and identify areas of action to enable data-driven planning and organisation of vocational education and training.

Based on the VET Statistics, various indicators can be calculated that give insights into different developments within the VET system (according to BBiG/HwO) in Germany (see Dionisius et al. 2024). One such indicator is the VET Entry Rate (German: Ausbildungsanfängerquote, or AAQ), which provides information about the proportion of individuals who begin a VET programme at some point in their lives. This indicator not only gives an overview of the quantitative significance of the VET system in Germany but also provides insights into its integrative performance with regard to different demographic groups.

A significant part of the analyses and the indicators developed based on the vocational education statistics are also included in the Vocational Education Report of the federal government and the Data Report of the BIBB.

The VET Entry Rate is first presented in detail in terms of its definition, purpose and method of calculation (chapter 2). In chapter 3, selected calculation results are presented to highlight the significance of the AAQ in monitoring the VET system, and finally, in chapter 4, an outlook is provided, addressing, among other things, the fact that the VET Entry Rate is not a rigid indicator but is continuously being developed and improved.

2 The VET Entry Rate

What is the quantitative significance of vocational education and training in Germany as an educational path after school? How well does the VET system integrate different groups of people? The VET Entry Rate (AAQ) helps to find answers to these questions. It is an indicator based on data from the VET Statistics that plays a significant role in evidence-based VET reporting.

The AAQ shows the proportion of the population that begins a VET programme (under BBiG/HwO). It was developed by the BIBB following the revision of the VET Statistics in 2005 and has been used as an indicator of participation in VET since 2009 (see Schmidt 2024a).

A solid methodological basis is essential for ensuring that the AAQ as an indicator provides valuable insights into the state of and trends in VET, is easy to interpret and consistent over time, so that it provides a strong foundation for evidence-based policy decisions. In order to ensure this, the BIBB calculates the AAQ as a first-time entry rate following the OECD standard for calculating participation or entry rates in vocational education (see OECD 2017) (for more detailed explanations of the AAQ calculation, see Schmidt 2024a and Schmidt 2024b). Two different data sources are used: on the one hand, the number of first-time VET entrants is included in the rate, and on the other hand, population data from the population register of the Federal Statistical Office. Partial rates are calculated by relating the number of first-time VET entrants of a given age to the total population of the same age. These partial rates for each age group are then summed up to calculate the full VET Entry Rate – the AAQ.

Figure 1: Formula for calculating the VET Entry Rate (AAQ)

$$AAQ = \sum_{i = 16 \text{ (aged 16 or younger)}}^{i = 24 \text{ (aged 24 or older)}} \frac{\text{First time VET entrants}_i}{\text{Resident population}_i} \cdot 100$$

i = age; For the sake of simplicity, first-time VET entrants aged "16 and under" are grouped together in the lower age category, while those aged "24 and over" are grouped together in the upper age category. With regard to the population, each single-year age cohort from 16 to 24 is included in the respective partial rate.

Source: Dionisius et al. 2024

The described method is used because it has several advantages over "simple" rates. It calculates synthetic age cohorts, where the entry into VET may occur at any point in the person's life. One advantage of this approach is that the rate takes into account first-time VET entrants regardless of the age at which they enter the VET system. In contrast, a simple rate that related only selected age groups to the corresponding population would not capture those entering at older or younger ages. Furthermore, the method allows for meaningful comparisons with other educational sectors and countries where entries typically occur at a different age than in the German VET system (provided that the calculated rates in those other systems or countries also follow the described OECD method).

3 Regional and Group-Specific Relevance of the VET System

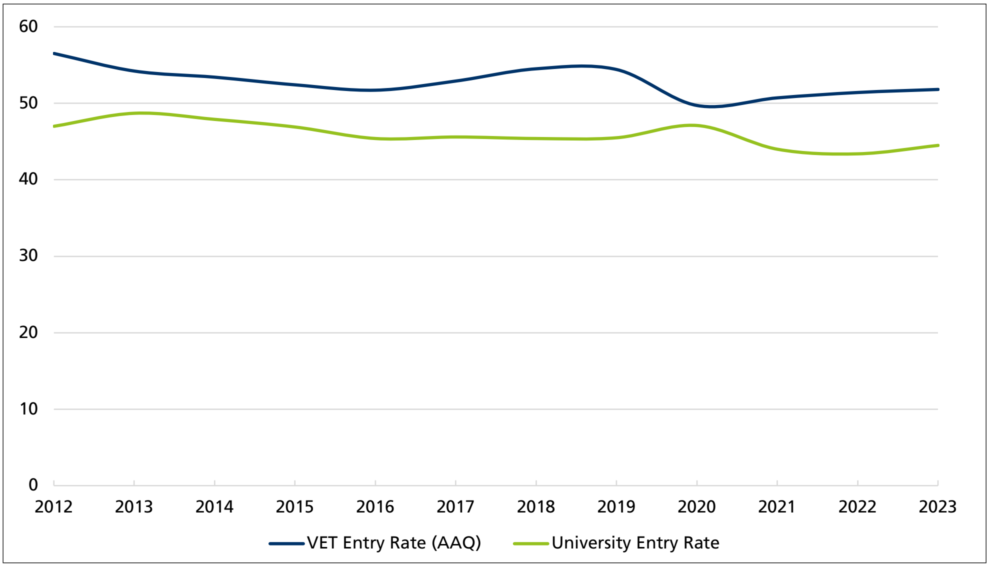
In 2023,[1] the AAQ was at 51.8 percent, highlighting the significant role of the VET system in the German vocational education landscape. It exceeds the University Entry Rate (German: Studienanfängerquote) (2023: 44.5%[2]), which is calculated by the Federal Statistical Office using the same OECD method as the AAQ (see Statistisches Bundesamt 2024; Schmidt 2026) for the German university system. That being said, over a longer period of time, the

1 2023 was the most current year for which data was available at the time of the editorial deadline.

2 The University Entry Rate cited in this publication is the rate without international students. "International students" refers to both German and foreign students who have obtained their higher education entrance qualification (HEEQ) abroad, as well as foreign students without information on the location where they obtained their HEEQ. The University Entry Rate without international students provides a better comparison to the AAQ, as individuals with an HEEQ obtained abroad are likely to play a significantly smaller role in the VET system than the university system. See Schmidt 2025 for further details.

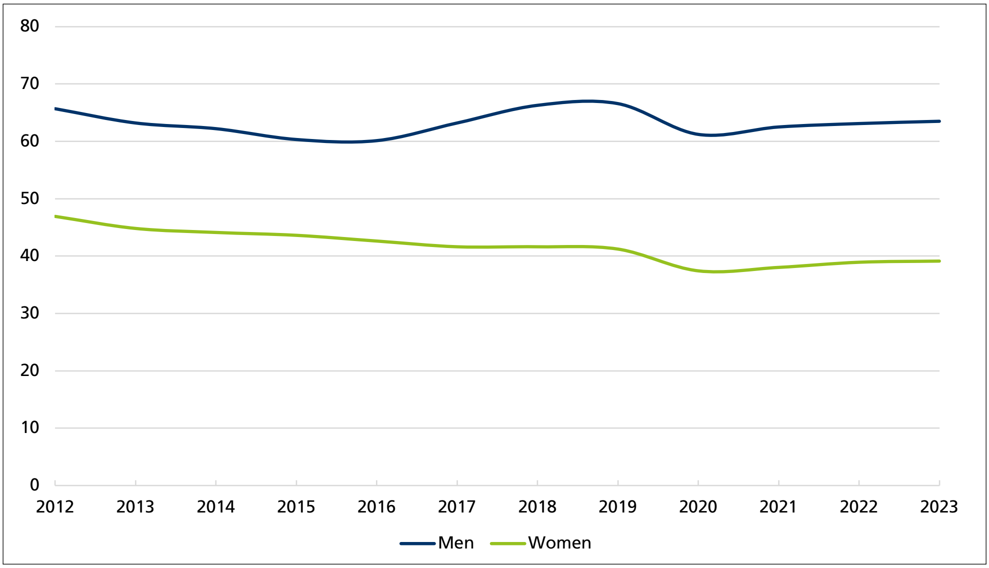
share of the population starting VET programmes (under BBiG/HwO) has shown a slight downward trend – in 2012, the AAQ was still at 56.5 percent (see Figure 2).

Figure 2: VET Entry Rate (AAQ) (in %) and University Entry Rate (in %), 2012 to 2023



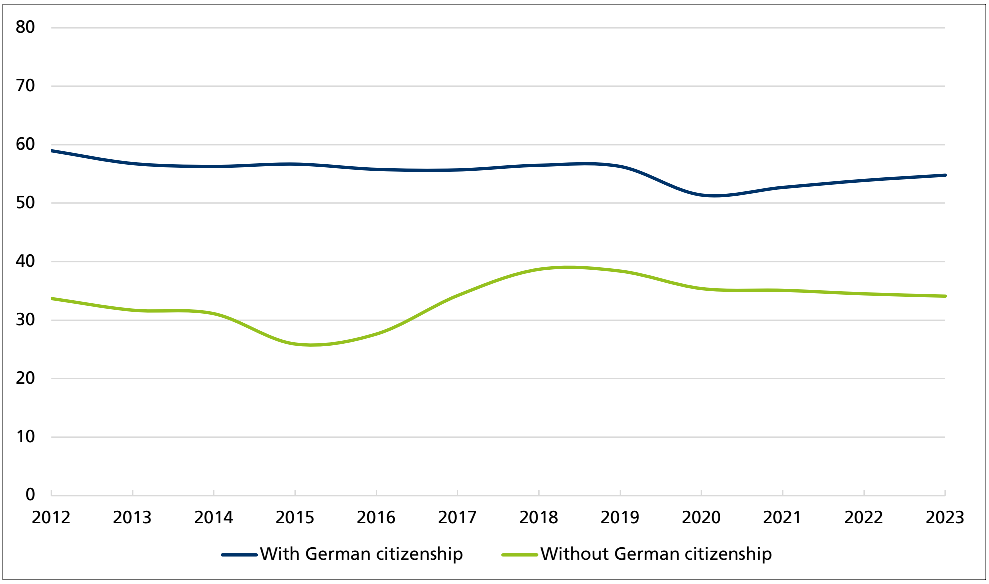
Sources: "Datenbank Auszubildende" of the Federal Institute for Vocational Education and Training (BIBB), based on data from the Vocational Training Statistics of the Federal and State Statistical Offices (31.12.); Population data from the Federal Statistical Office (population as of December 31st); Hochschulstatistische Kennzahlen des Statistischen Bundesamtes (Destatis).

Figure 3: VET Entry Rate (AAQ) (in %) by gender, 2012 to 2023



Sources: "Datenbank Auszubildende" of the Federal Institute for Vocational Education and Training (BIBB), based on data from the Vocational Training Statistics of the Federal and State Statistical Offices (31.12.); Population data from the Federal Statistical Office (population as of December 31st)

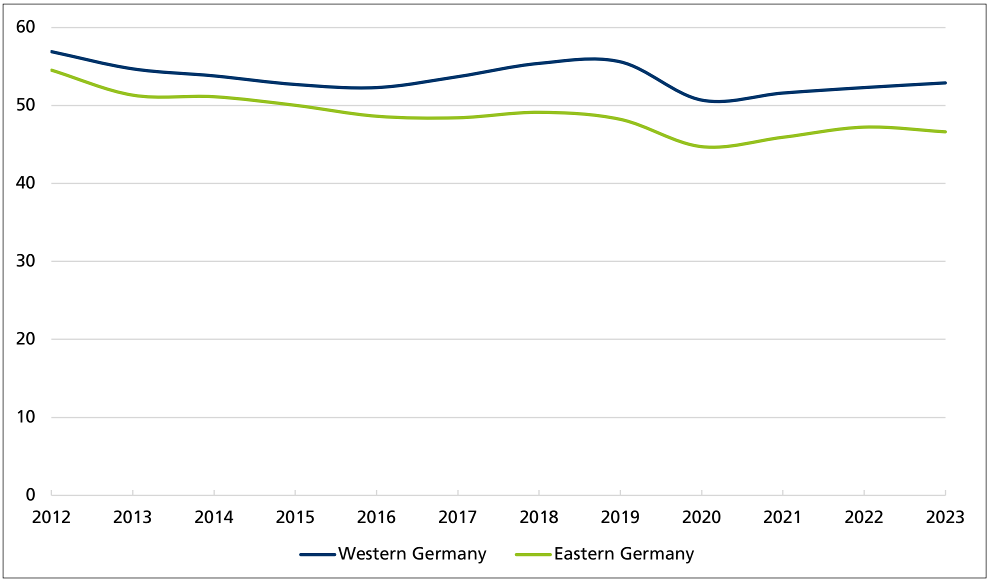
Figure 4: VET Entry Rate (AAQ) (in %) by nationality, 2012 to 2023



Sources: "Datenbank Auszubildende" of the Federal Institute for Vocational Education and Training (BIBB), based on data from the Vocational Training Statistics of the Federal and State Statistical Offices (31.12.); Population data from the Federal Statistical Office (population as of December 31st)

The AAQ also provides valuable insights by enabling the assessment of the ability of the VET system to integrate different groups of people: Which groups of people are more likely or less likely to opt for VET? This provides policymakers with information about where to focus their efforts to help more people get into VET programmes. For example, the AAQ is significantly higher for men (2023: 63.5%) than for women (2023: 39.1%) (see Figure 3), and for people with German citizenship (2023: 54.8%), it is significantly higher than for people without German citizenship (2023: 34.1%) (see Figure 4). Regional comparisons are also possible and can give policymakers initial clues about regional factors that might play a role in the likelihood of transitioning into the VET system. For example, in 2023, the federal states with the highest AAQs were Bavaria (58.8%), Mecklenburg-Vorpommern (56.1%), and Lower Saxony (55.5%), while the federal states with the lowest AAQs were the city-states of Berlin (31.4%), Hamburg (39.6%), and Bremen (45.7%). That the city-states are the states with the lowest AAQ suggests that there are differences in the VET entry likelihood between urban and rural areas. Overall, the AAQ in western Germany (2023: 52.9%) is higher than in eastern Germany (2023: 46.6%) (see Figure 5). However, the eastern German average is pushed down in particular by the low AAQ in Berlin, which has a strong influence due to its large population.

Figure 5: VET Entry Rate (AAQ) (in %) by region, 2012 to 2023



Sources: "Datenbank Auszubildende" of the Federal Institute for Vocational Education and Training (BIBB), based on data from the Vocational Training Statistics of the Federal and State Statistical Offices (31.12.); Population data from the Federal Statistical Office (population as of December 31st)

Additionally, the AAQ is insightful when looking at unexpected economic and societal developments and their impacts on VET participation. In recent years, events such as the

COVID-19 pandemic (see Kroll 2021; Oeynhausen et al. 2021; Uhly 2021) and migration to Germany of a large number of people in a relatively short timeframe in 2015/2016 as well as 2022/2023 (due to the Ukraine war) (see Schmidt/Kroll 2024) have had strong impacts on the VET system in Germany. For example, the COVID-19 pandemic and the resulting lockdown measures caused significant uncertainties, both for training companies and young people, leading to sharp declines in both the demand for and supply of VET positions in 2020, as well as an increase in problems matching the existing supply and demand in the VET market (see Oeynhausen et al. 2021). This resulted in a significantly lower number of newly signed training contracts (see Kroll 2021). The AAQ also shows this COVID-19 effect: it dropped sharply from 54.4 percent in 2019 to 49.7 percent in 2020 (see Figure 2). Since then it has slightly increased year over year, though it has not yet reached pre-pandemic levels. Large migration movements, especially in 2015/2016 and 2022/2023, have been another instance of sudden and unexpected societal developments that have impacted the VET system. The AAQ provides insights here as well: when a large number of refugees arrived in Germany in 2015, the AAQ among people without German citizenship[3] initially dropped significantly (2014: 31.1%; 2015: 25.9%). However, this initial decline does not indicate that refugees were poorly integrated into the VET system. Rather, it reflects the fact that while they were immediately counted as part of the population, a transition into VET programmes was not immediately possible or expected. More telling than the drop of the AAQ among people without German citizenship in 2015 is the large increase in the following years: between 2016 and 2018, the AAQ among people without German citizenship rose from 27.6 percent to 38.7 percent (see Figure 4) – an indication that refugees found their way into the dual system very successfully after a settling-in period of about two years. With the current situation with refugees from Ukraine, it will be interesting to see whether the development follows a similar pattern (see Schmidt/Kroll 2024).

4 The AAQ – An Indicator That Is Not Set in Stone

Due to its significance and the insights it provides regarding the development of the quantitative importance of the VET system compared to other education sectors, the impact of social and economic developments on VET as well as regarding the ability of the VET system to integrate different groups, the AAQ is frequently referenced in evidence-based educational reporting. It is discussed annually in the Vocational Education Report of the Federal Ministry for Education, Family Affairs, Senior Citizens, Women and Youth (BMBFSFJ) (see BMBF 2025) and is also analysed in detail in the associated VET Data Report (see BIBB

3 The VET Statistics record the nationality of trainees but not whether they have a refugee or migration background. Consequently, refugees cannot be clearly distinguished from non-refugees and it is therefore not possible to calculate the AAQ specifically for refugees. However, it is plausible to assume that the development of the AAQ among foreign nationals is likely to have been significantly influenced by refugees, particularly in the years 2015 to 2017 and again from 2022 onward.

2024)[4]. The AAQ is also regularly reviewed in the biennial Integration Report by the Commissioner of the German Federal Government for Migration, Refugees, and Integration (see Beauftragte der Bundesregierung für Migration, Flüchtlinge und Integration 2025) to compare the integration performance of the VET system for people with and without German citizenship.

However, even though the AAQ has been an established indicator in VET reporting for many years, it is not set in stone. For example, in 2009 the indicator was significantly revised by counting the number of first-time VET entrants instead of the number of newly signed VET contracts, leading to the new name "VET Entry Rate" instead of continuing with the old term "VET Participation Rate" (German: Ausbildungsbeteiligungsquote, or AQ). This revision of the indicator (made possible by the 2005 revision of the VET Statistics) drastically improved the indicator's significance by avoiding double counting of individuals (see Gericke 2012; Uhly 2012; Schmidt 2024a). Another major improvement occurred in 2022: since that year, first-time VET entrants can be assigned to a region based on their place of residence when calculating the AAQ (see Schmidt 2024a; Schmidt 2024b; Schmidt 2024c). This allows for the exclusion of first-time VET entrants with a place of residence outside of Germany, preventing an overestimation of the AAQ. Additionally, it opens the possibility for more detailed regional analysis, as regional discrepancies due to commuting movements can now be avoided. In the future, the AAQ will remain a "living" indicator, subject to adjustment and further improvement as the data basis allows. This way, it will remain a relevant and meaningful indicator for evidence-based educational reporting and subsequent decision-making in policy and practice.

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Monitoring and Follow-up of Costa Rican Dual TVET: Building a Contextualized System for Quality Assurance

In 2021, the technical team of the Advisory and Promotion Commission of Costa Rican Dual Technical Education and Training faced the challenge of preparing the first monitoring report on Dual TVET. In response to this challenge, a working team was formed. The first version of the monitoring model is prepared based on the guidelines proposed in the Dual TVET Law. For the year 2022, the need to develop a more robust model that facilitates follow-up with a focus on quality assurance is proposed. Based on the above, and with the advances made by the Observatory of TVET of the University of Costa Rica, in terms of a monitoring model for Costa Rican TVET, a limited and contextualized version is proposed for Dual TVET. Therefore, the purpose of this text is to describe the construction process of this model, with emphasis on its contextualization process, to demonstrate its contributions to quality assurance, accountability, and transparency in Dual TVET.

1 Introduction

TVET in Costa Rica has experienced a series of changes, improvements and, innovations that respond to different socio-historical periods and political, economic, labor and educational motivations at the national and international levels, which have favored the evolution, the creation of regulations and, the integration of new actors in the field of TVET.[1] Therefore, it is imperative to build systems to monitor these changes.

Therefore, the quality and relevance of TVET are of great importance, since it is necessary to have a set of indicators to evaluate the scope, access, governance, transition to the labor market, perception, among other key factors in TVET, to make improvements and offer a timely response.

Blom and Meyers (2003) state that the creation of indicators for monitoring and follow-up also allows for the documentation of quality, considering the context, the expectations of stakeholders, the training process, and the results of the training. In their research, they find that the quality indicators that have a universal presentation are performance,

1 Declaration of use of artificial intelligence: OpenAI, ChatGPT (Version 4.0). Responses were generated between 21 July and 25 July 2025, and were used exclusively to assist with writing and style editing. Copilot 365 based on OpenAI's GPT-4 model. Responses were generated between 21 July and 25 July 2025 and were used exclusively for the English translation of the tables.

participation, progression, permanence, success, and completion, as well as the nature of the learner's experience and the human, physical, and financial resources that support it.

Based on the reasoning of these authors, the importance of developing the indicators that make up the monitoring and follow-up system for Costa Rican Dual TVET was established, which has made it possible to have data that make progress visible and contribute to decision-making within each educational program and for the CAP – DUAL TVET. Also, because the country progress report is made as part of the mandate established in the Dual Technical Education and Training Law, among the functions attributed to the Advisory Commission, article 12, paragraph c; therefore, having the system of indicators and monitoring was necessary for the preparation of the annual report.

2 Theoretical Framework

The following first establishes how Costa Rican TVET is understood, in the case of Dual TVET, and then presents the theoretical references for each of the dimensions established in the monitoring and follow-up system.

2.1 Conceptualizations of TVET and Costa Rican Dual TVET

The following is a synthesis of conceptualizations of TVET based on Costa Rican regulations that have been generated around the historical conformation of the educational modality. The first record is found in the Fundamental Law of Education (Law 2160) (Legislative Assembly 1957), which states in Article 17, that VET refers to careers of vocational or professional nature of medium grade, which are established according to the needs of the country and the peculiar characteristics of the professions or trades.

In this conceptualization, it is emphasized that for Technical Education within the framework of the Ministry of Public Education, the Higher Council of Education is established as the governing body, and it is emphasized that the study programs respond to the needs of the country concerning the employment system, which establishes the linking between the educational system and the economic system from its first conceptualization.

Subsequently, in 1965, with the Law of Creation of the National Learning Institute (INA) (Law 3506) (Legislative Assembly 1965), it is stated that the INA oversees Vocational Education and Training (VET) for adults, to meet the needs of the economic system, and to contribute to national development. In addition, Article 11 states that the curricula are developed based on a consultation with public and private institutions on their qualification needs. This is reinforced by what is stated in the Regulations to the Organic Law (Executive Branch 1984), that the purpose of vocational training is to develop knowledge so that people can be inserted into the labour system. In addition, the National Qualifications Framework for Technical Vocational Education and Training (Arias et al. 2019) states that Technical Vocational Education is an educational way that "favours the incorporation of people into the labour field and promotes comprehensive training. It provides equal opportunities in terms of equitable and non-discriminatory access" (p. 36), which for the first time includes the aspect of comprehensive training that allows generating equal opportunities for insertion into the labour market.

A year later, in the General Regulations to the Law on Dual Technical Education and Training (Executive Branch 2020), reference is made to the fact that TVET "is conceived as a mechanism of upward social mobilization that guarantees the relevant preparation of human resources in areas of high demand and growing salaries, for the benefit of vulnerable populations", which allows visualizing it as a mechanism of social mobilization, which allows people to insert and remain in the labour markets, affecting the quality of life of vulnerable populations.

In 2022, Executive Decree 43481 (Executive Branch 2022) Creation of the National System of Technical Vocational Education and Training (SINEFOTEP) was approved, which states that TVET is understood as a

> "field of education that deals with imparting knowledge, skills, abilities and attitudes required to adapt to a changing environment, through quality, structured and comprehensive training, which allows active and responsible participation in society and the world of work, whether formal, non-formal and informal. Promoting understanding, respect for human rights, inclusion, equity, gender equality, cultural diversity, the ability to learn throughout life, and learning to live together."

In this last conceptualization, the conceptual turns that were being visualized in previous laws are concretized, since in the first instance its contribution to the assurance of human rights and social justice for all populations is made explicit.

2.2 Theoretical definition of dimensions for Dual TVET indicators

UNESCO (2016) establishes that the Education 2030 agenda places special emphasis on the development of technical and vocational skills, especially about affordable and high-quality access to TVET. It also refers to the need to provide opportunities for the development of technical skills linked to employment, decent work, and entrepreneurship. To eliminate gender inequalities and ensure access for the most vulnerable. This reference provides a basis for the access and coverage dimension, as it allows for establishing the aspects considered within the proposed indicators.

To support the curriculum's scope, the three priority areas for TVET (UNESCO 2016) were considered. These areas refer to the need to foster youth employment and entrepreneurship, the promotion of equity and equality between men and women, and the importance of moving toward green economies and sustainable societies.

In addition, Arias et al. (2019) stated that TVET in Costa Rica focuses on comprehensive training, which includes technological and technical aspects for timely entry into the labour market. Furthermore, the authors propose that the TVET curriculum should facilitate

> "the harmonious development of personality; It fosters the ability to understand, judge, critically analyses, and express oneself assertively; it prepares for lifelong

> learning through technological tools, knowledge, abilities, skills, and attitudes; it develops the capacity to adapt to social and technological changes, decision-making, active participation, teamwork, and entrepreneurship development" (Arias et al. 2019, p. 37).

Regarding the dimension of the link with the labour market, it is recognized that TVET structurally enables the connection of two systems, the educational and the economic systems. However, it is argued that the coordination between the two varies from context to context but also includes coordination within the curriculum (Albashiry et al. 2015). How the systems are linked can be made visible and measured at each stage of the curriculum planning and implementation process (Rageth/Renold 2019). The effectiveness of TVET educational programs depends on the quality of this link (Bolli et al. 2018).

In addition to the above, the structural coupling between systems that occurs in TVET is recognized, which requires coordination in all aspects, as well as a distribution of power and control, which leads to shared decision-making (Camacho 2024a).

For the dimension of equity, equality, and poverty, the foundation was established as established by UNESCO (2016) on the need to "define appropriate regulatory measures to promote equity in and through TVET; ensure that all young people and adults, women and men, have the same opportunities to learn, develop and increase their knowledge, skills and competencies, and meet highly diverse learning and training needs" (ibid. p. 9). As well as what was stated on the need to create strategies "aimed at promoting women's access to occupational fields that offer better employment prospects, the definition of relevant and promising international practices, including in terms of improving the monitoring and evaluation of equality between men and women in TVET" (ibid. p. 10).

Specifically, to support the Teacher and Mentor Training dimension, Manning's (2016) approach to the need to monitor the performance of teachers and mentors in TVET, as well as ensuring their professional development and upgrading, was considered. This is established as a challenge due to the need to have the skills to link theoretical teaching and pedagogy with practical and technical teaching. Therefore, teachers and mentors must combine all the skills. Finally, regarding governance, there is a need to have good relationships between teachers, mentors, companies, educational centres, and governments, to have national TVET systems that enable upward social mobility. To follow up on this, monitoring and evaluation systems are necessary to ensure quality (Manning 2016; Camacho 2024a).

3 Results

3.1 Development of the monitoring model

In response to the need for a robust monitoring system, the CAP – DUAL TVET secured technical support from the TVET Thematic Observatory (OBEFOTEP), affiliated to the INIE of the University of Costa Rica. This collaboration generated the technical document "Dimensions and Indicators for Monitoring Dual TVET" (Equipo Técnico CAP EFTP Dual 2023), which defines the priority dimensions and measurement indicators for the modality (ibid.).

The document was prepared by a working group composed of the CAP – DUAL TVET and OBEFOTEP and validated by the institutions of the Technical Team. This inter-institutional validation ensured the relevance and viability of the indicators before their implementation. Since the 2022 annual report, the CAP has adopted this set of dimensions and indicators to monitor the development of the dual modality, which was fully consolidated in the 2023 and 2024 reports (Equipo Técnico CAP EFTP Dual 2023; 2024).

3.2 Monitoring dimensions

The model structure is around six key dimensions that address critical aspects of Dual TVET implementation. These are access and coverage, curriculum, linkage to the labour market, equity, equality and poverty, teacher and mentor training, and governance. Table 1 presents these dimensions and their definitions.

Table 1: Dimensions for monitoring Dual TVET

Dimension	Definition
Access and Coverage	Strategies, elements, and mechanisms that demonstrate the coverage, quality, resource deployment, and access to Dual TVET services.
Curriculum	Relevance of the Dual TVET curriculum about the context, technologies, and comprehensive training.
Link to the Labor Market	Mechanisms to coordinate actions between the educational and productive sectors in the implementation of Dual TVET.
Equity, Equality, and Poverty	Strategies and affirmative actions to guarantee equal opportunities and address the needs of vulnerable groups.
Teacher and Mentor Training	Actions to ensure the quality of training for key stakeholders in Dual TVET.
Governance	Monitoring and evaluation systems to ensure the quality of the offering and the coordination of stakeholders.

Source: Prepared by the authors based on Equipo Técnico CAP EFTP Dual [Advisory and Promotional Commission for Dual TVET] 2023; 2024

3.3 Detailed description of the dimensions

The six dimensions and the main indicators associated with each are described in detail below. In the Access and Coverage dimension, basic quantitative indicators were established, such as the number of educational institutions offering dual programs, the number of enrolled students, the number of participating teachers and mentors, the number of dual program graduates, and several agreements with companies or employability training centres, among others.

Likewise, indicators related to student protection were included, such as the number of students covered by the occupational risk insurance policy specific to dual training and the procedures associated with said policy (e.g., insurance processing, claims handled), in coordination with the INS.

In the Curriculum dimension, indicators have been proposed to measure dual education offerings and their updating, such as the number of existing dual TVET programs (disaggregated by economic sector), programs under design or planned for the future, the existence of a specific educational model for dual education, and a description of key processes (curriculum design for new programs, student admissions and vocational guidance processes, curriculum update mechanisms, and monitoring processes for the implementation of dual programs in institutions).

These indicators allow for assessing the relevance and dynamics of curricular improvement in the modality. Regarding the link with the labour market, the indicators cover the degree of involvement of the productive sector in the dual modality. The number of companies that have hired graduates from dual programs (as a measure of job placement success), the actions of linking or collaborating between educational and business actors (for example, working groups, public-private agreements, strategic alliances promoted by the CAP – DUAL TVET or other organizations), and the participation of employers in curriculum development (i.e., in the definition of graduate profiles, required competencies, and training content) are considered.

The Equity, Equality, and Poverty dimension incorporates indicators aimed at monitoring inclusion and diversity in dual programs. These include: the number of women enrolled (to demonstrate progress in gender equity in traditionally male-dominated areas), the number of students with disabilities enrolled, the number of international students served, and the number of students who dropped out or were excluded before completing the program (dropout indicator). Additionally, financial support for vulnerable student populations is measured, such as the number of scholarships awarded to dual students (by institutions such as the Ministry of Education (MEP) or the National Institute of Education (INA)) and the number of student loans granted to finance dual studies (for example, through CONAPE). These data provide insight into how the dual program is serving populations in poverty or vulnerability and its accessibility.

The Teacher and Mentor Training dimension contains indicators that assess the training and professionalization efforts of those implementing the dual approach. It includes the number of teachers specifically trained in the dual approach (at the Ministry of Education, the National Institute of Public Education (INA), or other training institutions), the number of business mentors trained by the legal requirement (remembering that Law 9728 requires training for mentors in companies; the National Institute of Public Education (INA) is responsible for this indicator), and the number of induction processes conducted for new teachers/mentors entering the approach.

The existence of teacher training programs at universities that include dual TVET courses in their curricula was also identified, which would demonstrate the sustainability of the training of future trainers. Finally, the dissemination and training activities carried out regarding dual TVET (such as courses, seminars, and webinars organized by various entities) are recorded, as well as, in coordination with regulatory institutions, the training efforts of labour and social security inspectors in the specific inspection procedures for companies participating in the dual modality. This last aspect is key to ensuring safe and regulatory-compliant work-learning environments.

Finally, the Governance dimension assesses inter-institutional coordination and management mechanisms within the dual TVET system. This dimension measures the number of coordination actions undertaken among actors in the dual TVET ecosystem (e.g., CAP – DUAL TVET sessions and agreements, working groups between ministries, the productive sector, and academia, cooperation agreements, joint promotional campaigns, etc.), as well as the existence of reliable information systems for recording and sharing system data (one identified challenge has been the creation of an integrated dual TVET information system, involving institutions such as CONARE and CONESUP in data collection from the university sector).

3.4 Indicators by dimension

Specific indicators were defined for each dimension, and sources of information and responsible institutions were identified for each one. Table 2 summarizes these indicators along with the type of information they collect.

Table 2: Indicators by dimension, information collected

Dimension	Indicators	Information they collect
Access and Coverage	Enrolment, graduation, teachers and mentors, policies, company-education agreements, perception of stakeholders.	Quantitative: population served, geographic coverage, participating companies. Qualitative: perception of satisfaction, trust, credibility.
Curriculum	Number and level of programs, design processes, pedagogical models, educational policies, curriculum monitoring.	Status of current and planned programs, curricular relevance, alignment with standards.
Link to the Labor Market	Companies that employ graduates, business participation in curriculum design, promotional activities.	Effective participation of the private sector, coordination mechanisms.
Equity, Equality, and Poverty	Enrolment by gender, disability, migrant status, scholarship granting, dropout rate.	Affirmative actions to ensure inclusion, equity, and access.
Teacher and Mentor Training	Initial and ongoing training, induction, perception of satisfaction, teaching careers that include dual training.	Key human resource capacities for implementation.
Governance	Coordination actions, information systems, evaluations, research, career permeability.	System quality, transparency, inter-institutional coordination mechanisms.

Source: Prepared by the authors based on Equipo Técnico CAP EFTP Dual 2023; 2024

3.5 Data collection process

Once the framework of dimensions and indicators was defined, the Technical Team proceeded to operationalize data collection for the annual report. Collection instruments (matrices in Excel format and online forms) were developed based on the agreed-upon indicators. In January 2024, the Coordination of the CAP – DUAL TVET Technical Team issued official communications requesting information from all involved entities, attaching these matrices and clear instructions.

The request was structured by sector as follows:

- **Education Sector:** Ministry of Public Education (MEP), National Learning Institute (INA), National TVET Qualifications Framework, National Council of Rectors (CONARE), National Council of Private Higher University Education (CONESUP), and Higher Education Council (CSE). These entities report data on dual education institutions and programs under their purview.
- **Ministries and Autonomous Institutions:** Ministry of Labor and Social Security (MTSS), Ministry of Science, Innovation, Technology, and Telecommunications (MICITT), Ministry of Economy, Industry, and Commerce (MEIC), Costa Rican Social Security Fund (CCSS), National Insurance Institute (INS), and National Education Loan Commission (CONAPE). Information related to regulations, insurance, labor inspections, educational financing, etc., related to state support for dual education is compiled here.
- **Business Sector:** Costa Rican Union of Chambers and Associations of the Private Business Sector (UCCAEP), the cooperative movement (mainly CONACOOP, CENECOOP, and INFOCOOP), and the free trade zone regime (Association of Free Trade Zone Companies – AZOFRAS). These actors provide data on company participation in dual training, student participation, and public-private partnerships in event organizations.
- **Social Sector:** Includes the education sector's union movement (Union of Costa Rican Educators – SEC), the National Assembly of the Youth Advisory Network, and the Solidarity Movement. Information was obtained from these organizations regarding their involvement in disseminating the modality, monitoring rights, and their perceptions of the implementation of dual TVET.
- **Other Organizations:** The CAP – DUAL TVET Technical Team also compiled contributions from organizations such as the Business Association for Development (AED), the Konrad Adenauer Foundation (KAS), and the International Labor Organization (ILO) Office in Costa Rica, as well as from binational and industrial chambers (e.g., the Costa Rican-German Chamber of Commerce and Industry, the Chamber of Industries of Costa Rica) and professional associations such as Colypro. These organizations, while not directly implementing dual TVET programs, have provided technical input, training, or studies related to dual TVET.

These entities provided quantitative and qualitative data based on the assigned indicators, thus consolidating the information necessary for the preparation of the Third Report (2023) and Fourth Report (2024).

4 Conclusions

The implementation of the contextualized monitoring and follow-up system for dual TVET in Costa Rica has represented a substantial advance in quality assurance, accountability, and transparency in this modality. The agreed-upon definition of dimensions and indicators provides a comprehensive framework for evaluation, ranging from inputs – such as resources, trained personnel, and current regulations – through processes – including curriculum design, inter-institutional coordination, and teacher training – to observable outcomes, such as graduate job placement, reduced gender gaps, and improvements in system management. This systemic approach allows for a full understanding of the dual modality in its complexity and avoids limiting the analysis to isolated or decontextualized data.

The active participation of various key institutions and sectors in generating and reporting information has strengthened inter-institutional coordination and promoted shared responsibility among stakeholders. The reporting institutions have recognized the importance of the indicators within their purview, which has encouraged the strengthening of their own recording and monitoring systems. However, the process has highlighted the need to move toward more integrated and reliable information systems, especially to consolidate data from the university sector and ensure greater consistency and quality in the records. This finding, identified through annual monitoring, constitutes a starting point for new corrective and improvement actions.

Likewise, the monitoring system has strengthened the evidence-based management capacity of the CAP – DUAL TVET as the coordinating body. The results of the annual reports have guided the systematization of recommendations and subsequent prioritization of strategic actions to be implemented by the various stakeholders in the Dual TVET system.

The presentation of results organized by dimension provides a clear understanding of the progress made, the conditions under which the modality is developed, and the challenges that remain. This exercise, in addition to fulfilling the legal obligation to report and be accountable, fosters confidence in dual TVET as a public policy subject to monitoring and continuous improvement.

Finally, the system has fostered an ongoing process of institutional learning and innovation. Each cycle of data collection and analysis provides valuable input for adjusting strategies and enriching interventions in the short and medium term. The participation of OBEFOTEP and the organizations of the Technical Team in the interpretation of the results ensures a critical and constructive perspective, linking technical management with educational research. The very construction of the system – through participatory and collaborative validation – constitutes a good practice that demonstrates the country's capacity to generate quality, participatory, contextualized, and relevant models. As the model evolves, it will be possible to incorporate new indicators and dimensions – such as the quality of

Dual TVET in companies or the satisfaction of students and employers – to broaden and deepen the assessment of the modality's impact.

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The Youth Explorer: Building Layers of Knowledge – A Case Study of TVET Colleges

The Youth Explorer provides information that can support policy planning and implementation for the entire trajectory of South African youth from learning to earning. It is an open-source, interactive spatialisation platform, with multiple layers of information and functionality. The platform displays a range of indicators of youth well-being, which can be overlaid with the location and information of a range of essential services, including Technical & Vocational Education and Training (TVET) colleges. Combining these data enables a gap analysis of the availability of services in areas of greatest need. The Youth Explorer is a key partner of the Presidential Youth Employment Intervention (PYEI), and is tasked with providing the 'single source of truth' for accurate data on youth. A recent TVET pilot study was undertaken by the PYEI, utilising the Youth Explorer data in an effort to guide TVET programme design and delivery.

The Youth Explorer

The Youth Explorer[1] is a South African open-source, interactive data driven platform aimed at policymakers and practitioners, to assist in evidence-based intervention and policy planning. The platform displays a range of indicators of youth well-being, as well as numerous youth labour market indicators, which can be overlaid with the location and information of a range of essential services, including Technical & Vocational Education and Training (TVET) colleges. Combining these data enables a gap analysis of the availability of services in areas of greatest need. The indicators of well-being are developed using the full 2011 census data (Statistics South Africa, 2015); the labour market indicators are based on the Spatial Tax Panel (Nell/Visagie 2024), as well as the 10 percent sample of the 2011 census (Statistics South Africa, 2015); and the service point data are largely collected in partnership with government departments.

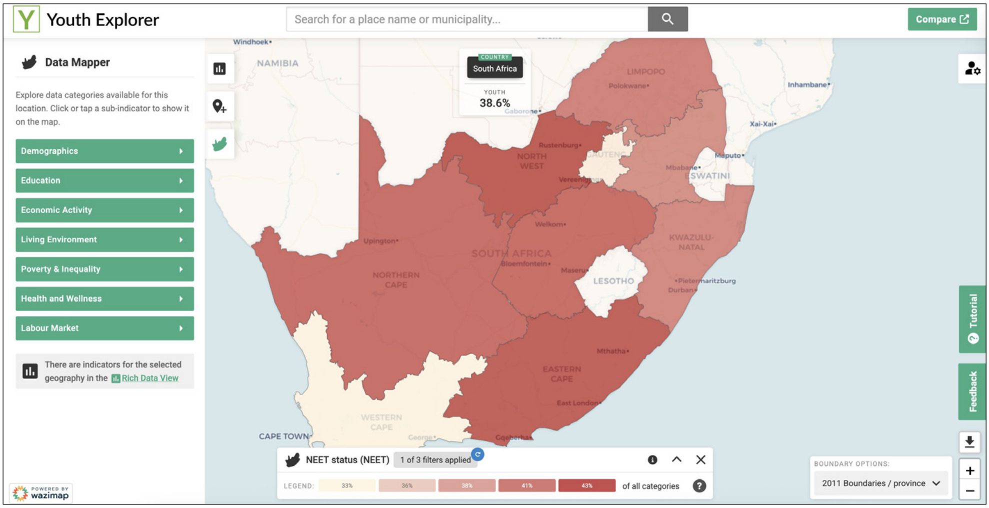
The first layer of knowledge available on the Explorer consists of the indicators of both youth well-being and the labour market. These detailed indicators are available from the national, down to the small area level. This small area level understanding is crucial: in the context of TVET colleges, for instance, understanding the local youth cohort and the communities they are tasked with serving is vital, alongside details on the local labour market that young people need to be able to find entry to. To provide a comprehensive view of youth well-being, the indicators relate to the following domains: demographics, education, economic activity, living environment, poverty and inequality, health and wellness, and the labour market. These domains and indicators were developed on the basis of literature

1 See URL: **https://youthexplorer.org.za/** (Retrieved on 01.04.2025).

reviews on youth well-being in South Africa, youth specific policy reviews, and extensive stakeholder engagements.

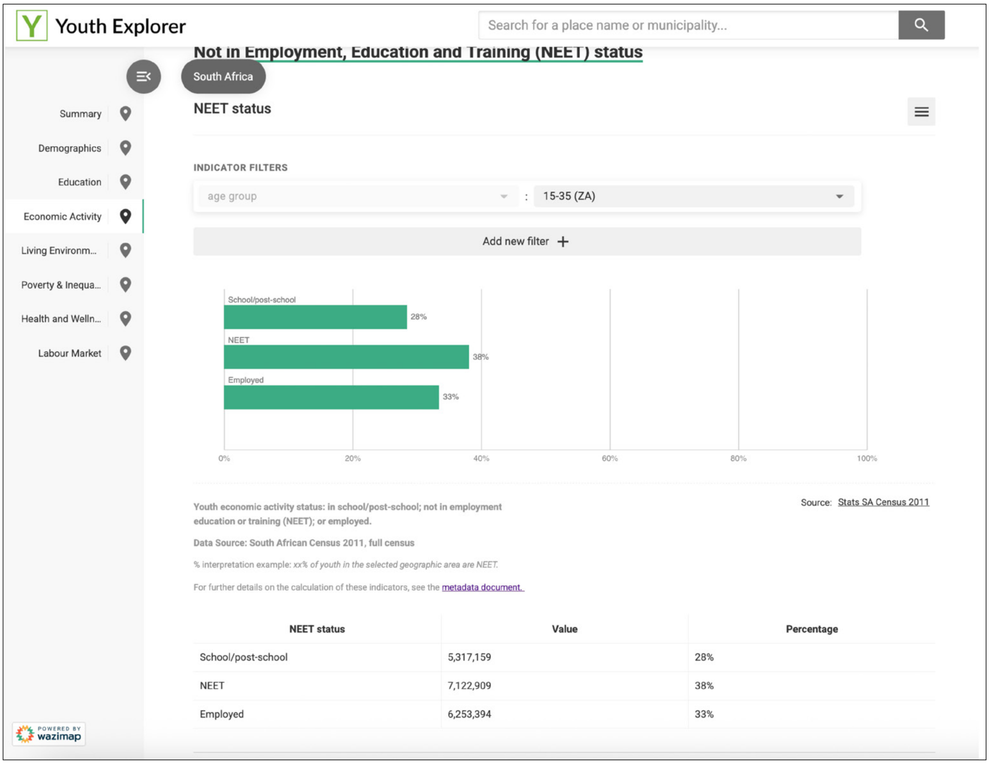
The indicators can be spatialised, as depicted in Figure 1 below, and graphed as shown in Figure 2; the data can also be downloaded in various formats directly from the platform for further analysis.

Figure 1: Choropleth map depicting the concentration of NEET youth at the provincial level



Source: Youth Explorer, SALDRU, UCT (https://geo.youthexplorer.org.za/).
Geography: South Africa; View: Data Mapper; Indicator: NEET status→NEET; Filter: age group 15–35 (ZA)

Figure 2: Graphical and statistical representation of NEET youth at the national level

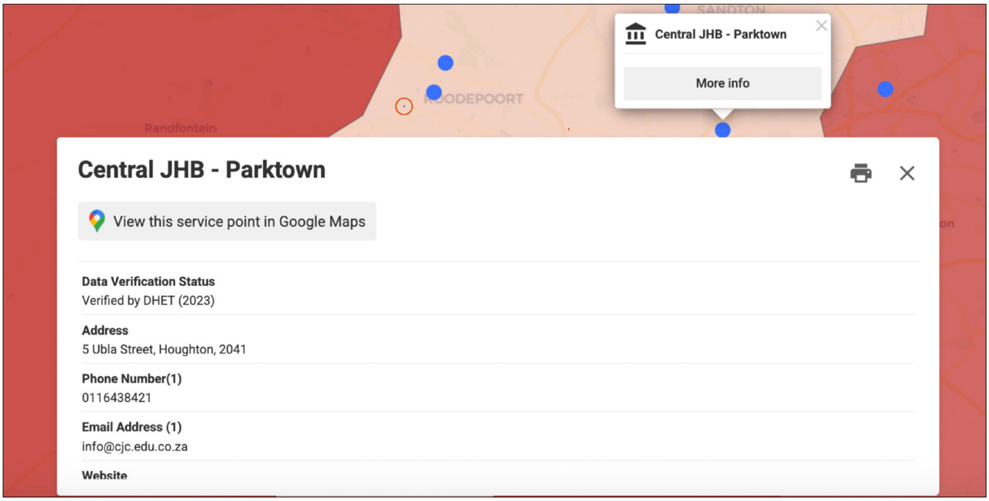


Source: Youth Explorer, SALDRU, UCT (https://geo.youthexplorer.org.za/).
Geography: South Africa; View: Rich Data; Indicator: Not in Employment, Education and Training (NEET) status→NEET status; Filter: age group 15–35 (ZA)

The second layer of knowledge on the Youth Explorer consists of service point information, including details on TVET colleges; this includes, e.g. exact location, opening hours and contact details.

Figure 3 provides an example of the information available for each TVET college. This information can be printed, and the location is linked to Google maps for ease of obtaining directions. An important note is that the TVET data has been verified by the Department of Higher Education and Training (DHET). The Youth Explorer team seeks, as far as possible, to work directly with government departments to collect and verify service point information. The verification status for each service point is noted in the information bubble.

Figure 3: Example of available TVET college information

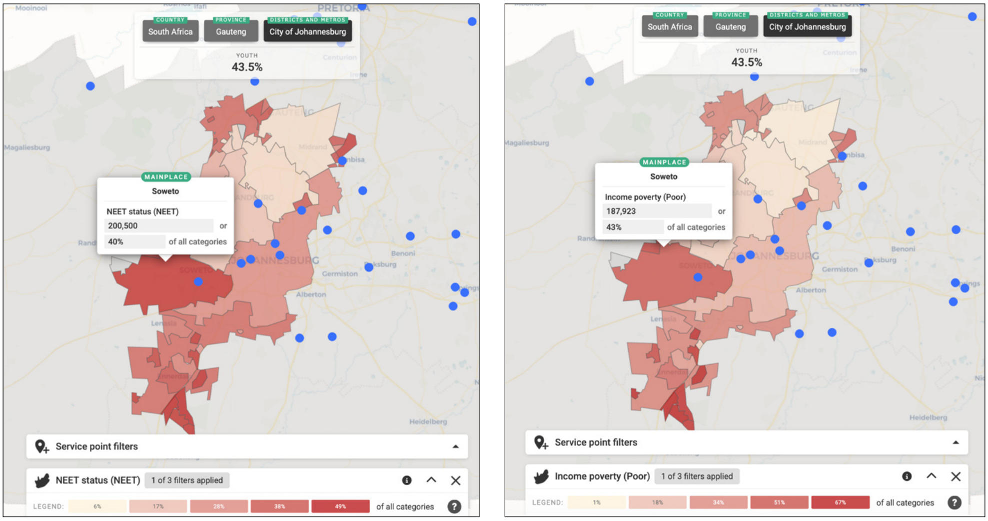


Source: Youth Explorer, SALDRU, UCT

All the service point data can be downloaded in various formats directly from the Youth Explorer for analysis outside of the platform. Working on the platform itself allows the user to overlay the various pieces of information for planning purposes. The following section provides an example of this.

A key feature of the Youth Explorer is that data is available at the small area level. While Gauteng province has the second lowest NEET rate, at 34 percent, the provincial level perspective hides pockets of deprivation within the province (SALDRU; University of Cape Town; OpenUp 2025). The first map of Figure 4 shows the NEET rate in the City of Johannesburg in Gauteng, overlaid with the location of TVET colleges. Within the metropolitan municipality, higher levels of NEET youth are observed in the South, for example, 40 percent in Soweto, relative to 11 percent in Sandton in the North. The second map reflects youth living in poverty, again reflecting considerably higher levels of deprivation in the South. In other words: areas such as Soweto house higher numbers of youth who are NEET and higher numbers of youth who live in income poverty. As a brief example of the gap analysis capabilities of the YE: the 200,500 NEET youth in Soweto are served by 1 TVET college. Many of these youth suffer multiple deprivations, including income poverty. This is equally true for youth even further South of Soweto, where not one TVET college is available. Attending a college would require resources not available among these young people. This provides an immediate indication of the need to (re)assess service point allocation across these geographical areas.

Figure 4: NEET youth, and youth living in income poverty, overlaid with the location of TVET colleges in the City of Johannesburg



Source: Youth Explorer, SALDRU, UCT (https://geo.youthexplorer.org.za/).
Left: Geography: City of Johannesburg; View: Data Mapper; Indicator: NEET status→NEET; Service point mapper→Higher Education→TVET Colleges; Filter: age group 15–35 (ZA)
Right: Geography: City of Johannesburg; View: Data Mapper View: Indicator: Income poverty; Service point mapper→Higher Education→TVET Colleges; Filter: age group 15–35 (ZA)

In addition, the Youth Explorer has a comparison tool where indicators can be compared across all the different geographic areas. Figure 5 shows that Soweto suffers a 40 percent NEET rate, 43 percent of youth live in income poverty, 29 percent of youth live in a household where no adult is employed, and 23 percent of youth live in multidimensional poverty. This last measure, the Youth Multidimensional Poverty Index (YMPI), is based on the Alkire-Foster Multidimensional Poverty Index (MPI) methodology (Frame/de Lannoy/Leibbrandt 2016; Alkire/Foster 2011). The YMPI quantifies the multiple and overlapping deprivations faced by youth across numerous youth-specific domains and indicators, including education, health, living conditions, and economic opportunities (Frame/de Lannoy/Leibbrandt 2016). On the other hand, Sandton has only 11 percent of youth who are NEET, 4 percent living in income poverty, 7 percent with no employed adult in the household, and 6 percent living in multidimensional poverty (SALDRU; University of Cape Town; OpenUp 2025). This highlights both the vast disparity within the City of Johannesburg, as well as the multiple deprivations faced by young people.

Figure 5: Comparison of youth living in Soweto and Sandton

Resulting comparison

Geography	NEET status NEET 15-35 (ZA)	Income poverty Poor 15-35 (ZA)	Household adult empl... No employed adult 15-35 (ZA)	Youth multidimension... Multidimensionally poor 15-35 (ZA)
Soweto	40%	43%	29%	23%
Sandton	11%	4%	7%	6%

Source: Youth Explorer, SALDRU, UCT

Finally, the Youth Explorer also includes data on the youth labour market, which, as detailed below in Figure 6, is an important factor in TVET college planning. Statistics are available for the number of Full Time Equivalent Employees, earnings, the number of establishments, worker occupations, whether these workers are in the formal or informal sector of work, as well as in which industry.[2]

Figure 6: Local labour market information on the Youth Explorer

Source: Youth Explorer, SALDRU, UCT

2 A metadata document linked on the Youth Explorer platform provides the details of exactly how the indicators are measured, and how to interpret them.

How the Youth Explorer has assisted TVET policy planning

The Youth Explorer is a key partner of the Presidential Youth Employment Intervention (PYEI), and is tasked with providing the 'single source of truth' for accurate data on government services catering to young people. The spatial gap analysis capability supports government departments such as the Department of Employment and Labour (DEL) and the Department of Higher Education and Training (DHET) in identifying 'service deserts' and infrastructure and service needs. Harambee, the organisation tasked with leading the National Pathway Management Network (NPMN) within the PYEI, hosts the youth-facing jobseeker support platform, SAYouth.mobi. Harambee uses Youth Explorer data to direct young people to the closest service point they require assistance from when they contact the SAYouth.mobi helpline. This allows the National Pathway Manager (Harambee) to better understand where services are underrepresented. These gaps can then be addressed in the structured engagements that exist between the Pathway Manager, DEL, National Treasury, and the Project Management Office in the Presidency.

The recent PYEI TVET pilot within the NPMN demonstrates the potential for a deeper, systemic integration of the Youth Explorer into TVET planning, curriculum development, and labour market alignment. The PYEI/NPMN TVET pilot intervention sought to:

- strengthen collaboration between public TVET colleges, employers, and NPMN partners such as Harambee and DEL,
- support TVETs to access work-integrated learning (WIL) opportunities within close proximity to the TVET, and improve student placement outcomes,
- enhance the use of labour market information (LMI) and youth service point data to guide TVET programme design and delivery,
- build TVET's capacity to network with employment-facing initiatives and better prepare students for real-world opportunities.

Essentially, the pilot aimed to close the gap between training and employment, by embedding TVET colleges more firmly into local labour markets and the broader youth employment ecosystem. Several critical needs and systemic gaps were uncovered through the pilot: colleges lacked up-to-date, area-specific information on employer needs and job opportunities; many TVETs have few systematic partnerships with local employers to support work placements or curriculum design; TVETs need better tools and networks to support career guidance, work readiness, and job search. Additionally, TVETs often lack dedicated staff or systems to engage employers and partners in a structured, sustainable way. And lastly, they struggle to understand how their training offerings align – or not – with youth needs in surrounding communities

By overlaying NEET rates, employer demand data, and TVET programme information, the Youth Explorer can help TVET colleges create actionable, area-specific labour market maps to guide programme planning and curriculum development. It can support stronger employer linkages by highlighting underserved geographic areas where work placement partnerships could be developed. Additionally, the Youth Explorer can enrich career guidance by offering TVET career centres or lecturers interactive maps showing pathways from training to employment opportunities, personalised to the local context. For college administrators, localised dashboards could strengthen institutional capacity by making external engagement more data-driven and strategic (for example, a dashboard showing youth unemployment rates, available employers, service points, and top training needs within a 50 km radius of a specific college). This means TVET leadership (placement officers, lecturers etc.) will have better tools to plan, make decisions, and work with outside partners (such as local businesses, municipalities, and training providers). Instead of reactive outreach, colleges could leverage data to design short courses or skill-building initiatives that align with the needs of local employers. Finally, by making training deserts and service gaps visible, the Youth Explorer can enable both TVET colleges and the relevant departments (DHET, DEL, and the PMO) to prioritise interventions and allocate resources more effectively.

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Tillmann L. Guenther and Julia Olesen

Skills Supply and Demand-Side Assessment in the Ashanti Region

This interview with Tillmann Günther, Education Specialist at UNICEF Ghana, explores the findings and implications of a skills supply and demand-side assessment in Ghana's Ashanti Region. Conducted under UNICEF's expanded focus on Skills for Employability and TVET, the study reveals critical mismatches between training and labour market needs – highlighting sectoral imbalances, insufficient ICT and agricultural training, and employer dissatisfaction with graduate readiness. Using the ILO's STED methodology, the research triangulated qualitative and quantitative data. It aims to inform national policy, strengthen institutional planning, and inspire similar regional studies for evidence-based reforms.

Julia Olesen[1]: Thank you for speaking with us today, Tillmann. To begin, why does UNICEF prioritise data and evidence in the education sector, and how has this informed your entry into the TVET subsector in Ghana?

Tillmann Günther: Data and evidence have long been a key area of support for UNICEF within the education sector. In Ghana, UNICEF has worked closely with the Ministry of Education to strengthen its Education Management Information System (EMIS), building capacities for the regular collection of accurate and relevant data, its analysis, and facilitating the publication of evidence-based reports such as Education Sector Analysis (ESA) and annual Education Sector Performance Reports (ESPR).

UNICEF has also supported the introduction and scaling of the Mobile School Report Card (MSRC), which captures weekly school-level data focused on accountability and performance indicators – such as teacher and student attendance, and class management. These efforts reflect UNICEF's broader commitment to data-driven decision-making, not just in Ghana but globally.

There's also significant interest among donors in strengthening data systems. For example, the Global Partnership for Education (GPE) has identified "data and evidence" as one of the enabling factors critical to transforming the education system.

Given this context – and UNICEF's recent decision to expand programming into Skills for Employability and the TVET (Technical and Vocational Education and Training) subsector in Ghana – we conducted a rapid stakeholder and intervention mapping. We observed that relatively few development partners were supporting data and evidence efforts in TVET. This presented a strategic opportunity for UNICEF to enter the subsector by building

1 This article was reviewed and translated with the help of AI. OpenAI, ChatGPT (Version 4.0), DeepL 12.08.2025.

a solid evidence base, engaging national actors such as the Ghana TVET Service and the Commission for TVET, and supporting the design of informed, impactful interventions.

Julia Olesen: Let's talk about the study itself. Which findings from the Skills Supply and Demand-side Assessment in the Ashanti Region stood out to you?

Tillmann Günther: Several findings confirmed widely held concerns but also provided new, region-specific insights. Chief among them is the persistent mismatch between the skills being supplied by training institutions and the skills demanded by employers.

In the Ashanti Region, there is a clear oversupply of graduates in trades like fashion and catering, while critical sectors such as agriculture, ICT, and technical fields face significant shortages. To illustrate this: over 39 percent of Ashanti's population resides in rural areas, and Ghana's One District One Factory (1D1F) initiative has stimulated demand for agro-processing and food manufacturing. Yet, despite 17 approved competency-based training (CBT) programmes in agricultural trades existing nationally, only one TVET institution in the region offers agricultural training. That's a striking gap.

Similarly, the ICT sector is expanding rapidly. The Ashanti Region – especially the city of Kumasi – is developing into an ICT hub, attracting foreign direct investment and demanding tech-savvy graduates. However, we identified only four TVET institutions out of 57 (35 public and 22 private) offering ICT training – clearly insufficient given the regional demand.

Another key insight was the perception gap between students and employers. Students often rate themselves highly in terms of job readiness, but employers in the area report dissatisfaction, especially regarding life skills and work ethics. These soft skills – punctuality, communication, integrity – are increasingly seen as essential, yet many graduates fall short in these areas.

The study also sheds light on the impact of Ghana's Free TVET policy, implemented since 2022. While it has led to a surge in enrolment, institutions are under pressure. Competency-Based Training (CBT), the national model for the delivery of quality TVET, demands a low pupil-to-teacher ratio (PTR) of 1:25, requires costly infrastructure, tools, consumables, and more sophisticated instructional methods. The increased enrolment can strain the ability of institutions to deliver high-quality instruction, with pupil-to-teacher ratios reaching 1:45 in some institutions.

Finally, workplace-experience-learning (WEL) emerged as both promising and problematic. Students are enthusiastic and employers are, in principle, supportive. However, employers express concerns about liability risks, unqualified students handling expensive equipment, and decreased productivity. These challenges highlight the need for better preparation and clearer guidelines for WEL programmes.

Julia Olesen: This was the first regional skills supply and demand assessment of its kind in Ghana. What challenges did you encounter in executing the study?

Tillmann Günther: The challenges were fairly typical for large-scale mixed-methods research but nonetheless noteworthy. First, the ambition was to cover all 57 public and private TVET institutions across the region. Given the distances between some of these institutions, field teams had to travel extensively, which extended the data collection timeline.

Second, while digital data collection is ideal, we had to revert to paper-based questionnaires in many instances due to internet and computer challenges. This led to back-and-forth delays – some forms were incomplete or misfiled, requiring follow-up visits. These are familiar logistical hurdles in education sector research but need to be factored into planning from the start.

Julia Olesen: You mentioned using a mixed-methods approach. Could you elaborate on the methodology?

Tillmann Günther: Yes. We used the ILO's Skills for Trade and Economic Diversification (STED) methodology, which provides a solid framework for assessing current and future skills needs across economic sectors. It has been widely tested in similar contexts across Africa and was therefore suitable for Ghana.

Our approach combined quantitative surveys and qualitative interviews with key stakeholders: students, graduates, employers, master craft persons (MCPs), and training providers. This allowed us to triangulate findings – for example, comparing how students perceive their readiness with how employers assess their preparedness. It ensured that our analysis was not only data-rich but also grounded in real-world perceptions.

Julia Olesen: Who are the intended users or beneficiaries of this study?

Tillmann Günther: The Ghana TVET Service is the primary beneficiary. They oversee all public TVET institutions, and this study provides them with critical evidence to guide planning and reform.

We have also started to work closely with the Commission for TVET (CTVET), which regulates the subsector. Importantly, the study is not a standalone research effort. It's part of UNICEF's broader aim to strengthen institutional capacity and evidence-based planning.

Beyond national agencies, development partners also stand to benefit. The findings can inform their own programme designs, not just in the Ashanti Region but potentially by prompting similar studies elsewhere or comparing trends across regions. Ultimately, the goal is to support better-aligned, context-sensitive policies and interventions.

Julia Olesen: Looking ahead, where do you see the greatest need for further research or data in the TVET sector in Ghana?

Tillmann Günther: Several gaps have emerged. First, even in the data space, there is a mismatch between supply and demand – different actors require different types of data, but it's often unclear who is responsible for collecting and sharing what. A national data mapping exercise could help: what data is collected? By whom? At what frequency? What are the gaps?

Second, regional studies like the one in Ashanti need to be replicated in other areas. The North of Ghana, for instance, has a different economic and demographic profile. A study in that region could surface different mismatches or needs.

Third, there is strong interest in tracer studies – tracking graduates to understand employment outcomes. Are they getting jobs, starting businesses, continuing education, or becoming unemployed? This is essential to not only evaluate the effectiveness of training programmes but to also make sure there are feedback loops of data and evidence into government practice and policymaking.

Lastly, we should revisit accountability and performance data at the school level. As mentioned earlier, the Mobile School Report Card could be expanded or adapted for the TVET subsector, offering timely feedback loops for administrators, educators, and policymakers alike.

Julia Olesen: Thank you very much, Tillmann. Any final thoughts?

Tillmann Günther: Just to emphasise that this study was not only about identifying problems but about enabling informed solutions. We hope it will serve as a foundation for policy and programme design – both for national actors and for partners working to improve the relevance and quality of TVET in Ghana.

Su Mon Phyo, Maw Maw Tun, and Zay Yar Aung

Labour Market Analysis and TVET Monitoring: Pathways for Human Resource Development in Myanmar

Myanmar's labour market is transforming due to economic growth, demographic shifts, and changing industry needs. This study analyses trends and skills gaps to align TVET programs with labour demand. Emphasis is placed on adapting formal, non-formal, and informal training to key sectors like manufacturing, construction, agriculture, and IT. Recommendations include strengthening School-Industry and Public-Private Partnerships, developing labour market-responsive TVET, integrating advanced technologies, and establishing a robust Labour Market Information System (LMIS) to support data-driven policies and improve workforce development.

1 Introduction

1.1 Labour Market Trends in Myanmar

Myanmar's labour force will increase in line with projected population growth.[1] According to World Bank data, Myanmar's working-age population (15 years and above) stands at around 35 million people (54 percent female, 44 percent male). The labour force is estimated at 24 million, 45 percent of whom are female (9.8 million) and 55 percent male (11.9 million).

With the projected growth in Myanmar's population estimated at 18 percent until 2050, the working-age population is expected to increase by 7 million, creating a total of 42 million people in the labour force. Growth will be highest among young (15–24) and prime-age workers (25–50 years old) (UNFPA 2022–2023).

Myanmar therefore needs to accelerate the pace of job creation and skills training to meet the labour demand and leverage the economic potential of this 'demographic dividend'1. According to UN Population Fund (UNFPA) projections, 3.7 million new jobs will be needed to keep employment on par with current levels (MOE 2021).

1.2 The Role of TVET in Bridging the Skill Gap

Despite improvements in recent years, the main constraint of the TVET system continues to be the mismatch between the TVET options offered and the skills required by industries. The Department of Technical and Vocational Education and Training (DTVET), Ministry of Science and Technology (MOST), has the vision "to continuously train and develop techni-

1 We acknowledge the usage of DeepSeek and ChatGPT for research in February 2025.

cal and vocational human resources in line with local needs to support the socio-economic development of the country" (DTVET 2024). Two missions of DTVET are to increase access to vocational educational for all who want to learn and to provide vocational training to help citizens find employment and increase per capita income.

To realize the visions and missions of the department outlined above, seven policies have been established. Under the Science, Technology and Innovation Strategic STISP (2022–2027) Five-Year Plan, the strategies and program components developed will be implemented year by year.

1.3 Monitoring System in TVET

Within the TVET Monitoring System, based on the STISP (2022–2027), which serves as a five-year roadmap, the Monitoring and Evaluation (M&E) Focal Person Team is responsible for undertaking the following tasks: implementing Department Annual Implementation Plan (DAIP), Annual Budget Reviews (ABR), Annual Performance Reviews (APR), Departmental Monitoring Report (DMR), and in addition, the mid-term and end-term evaluations of STISP (2022–2027) will also be carried out. The team ensures effective implementation, monitors ongoing activities, and facilitates collaboration to achieve the strategic goals of DTVET.

2 Overview of TVET in Myanmar

The government provides formal technical and vocational education and training courses in upper secondary education and tertiary education level as a part of the national education system. MOST and relevance ministries are implementing three-year TVET programs in upper secondary education as well as in tertiary education at designated TVET Institutions (MOST 2022).

Private and non-governmental organizations are implementing non-governmental TVET Programs, while they are providing the different training programs across the nation. The challenges occur in coordination, oversight and quality assurance of the national level TVET system due to the provision of diversified TVET programs in Asia.

The colleges, institutes, and schools currently opened by the MOST, DTVET total 139 schools: four Government Technological Colleges (GTC), 34 Government Technical Institutes (GTI), one Naypyitaw Polytechnic Institute (NPI), 35 Government Technical High Schools (GTHS), 59 Basic Education and Technical, Agricultural and Livestock High School (BETALHS), five Vocational Schools, one TVET Teacher Training College (TTTC).

2.1 Opportunities and Inclusion for All

Demand for more workers with modern skill sets will intensify with the ongoing diversification of Myanmar's economy as it shifts from its traditional reliance on low-skilled rural livelihoods towards the inclusion of industrial and service sectors. Many jobseekers today remain unskilled, with low educational attainment, and have not had an opportunity to develop their skills. Scaling up provision of TVET to reach many more young people will assist not only in meeting the skill needs of the growing economy, but also in meeting the employment aspirations of the increasing numbers of young people in their transition from school to work.

Expanding access to technical and vocational skills development for women, less opportunities and for persons with disabilities accompanied by measures to ensure labour market opportunities are open to them, will be important for unlocking the economic potential of Myanmar (MOST 2022).

2.2 Industry Relevance of TVET

The importance of linking the development of skills to current and emerging economic opportunities is not yet fully embraced by the TVET sector. Recent studies and reports (2023–2025) highlight that the shortage of skilled labour remains a critical barrier to business growth in Myanmar, exacerbated by political instability, economic crises, and systemic challenges (MOST 2022). These challenges can be addressed with a stronger overall vision and plan for TVET, mechanisms to anticipate labour market demand and to prioritize development of new programs in industry demanded areas.

Barring a few exceptions, there is a lack of significant private sector engagement in the development of TVET provision. Developing the regulatory framework to encourage public-private partnerships, creating spaces for linking TVET centres to private firms, establishing labour market observatories or conducting big data analysis to anticipate the demand, are some of the possible means to improve the relevance of TVET (MOST 2022).

2.3 Modern Management in TVET

Quality TVET teachers and trainers are the key factor for continuous improvement and innovation in teaching and learning in various learning venues; there are a number of challenges to be overcome before this is realized.

Modernized curricula alone will not transform the TVET learning experience – improving the quality of teaching and learning is a large but important challenge. The 2019 Mid-Term Review (MTR) of National Education Strategic Plan (NESP-1) found that there is a need to step up efforts to improve both pre-service and in-service teacher training, to develop pedagogical skills, practical skills and to embed modern transferable skills (MOE 2021).

2.4 Role of Public-Private Partnerships in Enhancing TVET Outcomes

To modernize its programs, TVET providers reach out a lot to their local community and employers, to national industry groups and to international organizations. There is a need for structured partnerships to provide industry guidance to TVET. Partnerships between schools and industry can be established at several levels, at the representational level (with industry leaders) at national or local levels, and also directly between TVET providers and local employers. The government has already established a high-level committee, the Human Capital Development Working Committee, to strengthen national coordination between the education sector and industry (represented by the Union of Myanmar Federation of Chambers of Commerce and Industry – UMFCCI), and this initiative is welcome and can lead to effective local committees. Other industry partnership models, including the forming of direct links between employers and providers, are also possible and highly desirable (MOST 2022).

3 Labour Market Analysis in Myanmar

3.1 Labour Market Statistics

Table 1: Estimated Labour Force Participation Rate by Occupation Type (2020–2023) (Values in %)

Occupation Type (Category)	2020			2021			2022			2023		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Managers	0.76	0.71	0.74	0.75	0.85	0.80	0.75	1.03	0.87	0.74	1.03	0.95
Skilled Agricultural, Forestry, and Fishery Professionals	1.39	5.28	3.03	1.38	5.31	3.03	1.37	5.31	3.01	1.35	5.31	3.00
Technicians and Associate Professionals	1.81	0.63	1.31	1.79	0.63	1.30	1.77	0.63	1.29	1.75	0.63	1.28
Clerical Support Workers	1.42	2.60	1.92	1.39	2.68	1.94	1.37	2.76	1.95	1.35	2.76	1.97
Service and Sales Workers	12.22	27.56	18.70	12.16	27.84	18.74	12.09	28.05	18.75	12.02	28.05	18.74
Skilled Workers in Agriculture, Forestry, and Fishery	36.59	27.97	32.95	35.14	26.71	31.60	33.78	25.52	30.33	32.49	25.52	29.13
Craft and Related Trades Workers	12.54	13.61	12.99	12.54	14.36	13.30	12.80	14.76	13.62	13.29	14.76	13.93
Plant and Machine Operators, Assemblers	9.91	1.11	6.20	10.51	1.11	6.56	11.10	1.11	6.93	11.68	1.11	7.29
Elementary Occupations	21.58	20.33	21.05	21.46	20.49	21.05	21.32	20.62	21.03	21.18	20.62	20.99
Others	1.78	0.20	1.11	2.88	0.02	1.68	3.65	0.21	2.22	4.15	0.21	2.72
Total (15+ years)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: MoL 2023a

Table (1) shows the percentage of workers by occupation type from 2020 to 2023. In 2020, skilled agricultural, forestry, and fishery workers accounted for the highest proportion at 32.95 percent (male: 36.59%, female: 27.97%). The second-largest occupational category was elementary occupations, namely manual laborers, domestic helpers and cleaners at 21.05 percent (male: 21.58%, female: 20.33%).

To systematically align labour market demands with education, skills, and sector-specific needs and to reduce graduate unemployment, the following measures are urgently required:

1. Enhanced coordination between government agencies and the private sector,
2. Collaboration with experts to establish a national labour market system,
3. Implementation of long-term strategic plans at the national level.

3.2 School and Industry Partnerships (SIP)

The SIP Program will be a key mechanism to bring together stakeholders and develop linkages and synergies between education, training, employment and regional development and economic growth.

The SIP Program will bring together Government Ministries, education and training providers, industry representatives, private sector companies and civil society stakeholders in each state and region to focus on the linkages and synergies between education, training, employment and regional development and economic growth.

4 TVET Monitoring in Myanmar

4.1 Indicators in TVET Monitoring and Evaluation

M&E in TVET is essential for assessing program effectiveness, efficiency, and impact, using specific, measurable indicators across key categories. The achievement indicators to measure the success of DTVET, a department responsible for developing human resources annually are:

- Number of students who attended in regions and states (GTHS, GTI, GTC)
- Number of students who received passing certificates
- Short-term training courses (number), trainees (number), trainees who successfully completed (number)
- Educational stipend funds and number of students receiving stipends
- Provision of teaching aids (types: teaching aids, office equipment, office furniture), total funds allocated
- Construction and major renovations of classrooms, workshops, staff housing, student hostels, and buildings (number)
- Capacity-building activities conducted (domestic, international)
- Participation in exhibitions and competitions, and awards received

- Signed agreements (MOU, MOA, LOA, LOI)
- Implementation of Quality Management System (QMS)
- Annual financial receipts and expenditures
- Total financial audit conducted

By tracking these indicators, TVET programs can ensure alignment with labour market needs, improve learner outcomes, and enhance program sustainability.

4.2 Alignment of TVET Curricula and Training Programs with Labour Market Needs

The current era is a time that necessitates comprehensive transformation in educational experiences, encompassing modern curricula in the fields of technical and vocational education and training; high-quality teaching and learning practices; robust assessment methods; and recognized certification systems. This period demands holistic changes across all aspects of education and skill development.

The curricula and learning materials are not frequently updated, and there is little formal linkage between teachers and the skills, knowledge and competencies needed by workplace.

This could be facilitated through the establishment of a new curriculum review framework, with a dedicated TVET curriculum review into how well 21st century skills needs are met. So, MOST has developed the capacity of the staff in the curriculum development team.

5 Key findings in TVET

5.1 Learning Opportunities, Quality of Programs

Technical and Vocational Education and Training (TVET) in Myanmar is essential for addressing skills gaps and improving employability, with opportunities provided by government-led programs, private sector initiatives, development partners, Non-Governmental Organizations (NGOs), and digital learning platforms. To strengthen TVET, Myanmar can focus on curriculum reform, industry collaboration, inclusive training, and digital transformation, supported by a national policy framework and sustainable funding. By addressing these challenges, Myanmar can build a robust TVET system to drive economic growth and social development.

These issues hinder the alignment of TVET programs with labour market needs and limit access for marginalized groups. To improve quality, reforms are needed in curriculum development, trainer professional development, and infrastructure investment, supported by stronger industry partnerships and inclusive policies. International organizations play a key role in supporting these reforms, but a comprehensive national TVET policy framework is essential for effective coordination and sustainability.

5.2 Effective TVET Management System

An effective TVET management system in Myanmar requires strong governance system, industry collaboration, and adequate resource allocation. Currently, the system is fragmented, with multiple ministries overseeing different aspects, leading to inefficiencies. Strengthening coordination among stakeholders, including government agencies, private sector partners, and educational institutions, is essential for improving program quality and relevance.

Additionally, increasing public awareness about the value of vocational education and securing sustainable funding are key to building a more robust and responsive TVET system that meets the country's workforce demands.

6 Recommendation for TVET

To strengthen TVET systems, it is recommended to align curricula with industry needs through active employer engagement, modernize training infrastructure, and invest in continuous professional development for trainers to enhance their technical and pedagogical skills. Establishing robust monitoring and evaluation frameworks will ensure data-driven decision-making and accountability, while inclusive policies should be implemented to improve access for marginalized groups, including women, rural populations, and persons with disabilities. Developing a comprehensive national TVET policy framework will provide coherence and coordination among stakeholders, and fostering public-private partnerships can enhance resource mobilization and program relevance. Additionally, integrating emerging technologies and promoting lifelong learning opportunities will ensure that TVET systems remain adaptable to evolving labour market demands, ultimately driving economic growth and reducing unemployment.

6.1 Establishing a Robust Labour Market Information System (LMIS)

Establishing a robust Labour Market Information System (LMIS) in Myanmar is crucial for aligning workforce supply with industry demands. A well-structured LMIS can provide accurate and timely data on employment trends, skills gaps, and emerging job opportunities, helping policymakers, educators, and businesses make informed decisions. Key steps include developing a centralised database, improving data collection methods, and strengthening collaboration between government agencies, employers, and educational institutions. Additionally, integrating digital technologies and ensuring accessibility to stakeholders will enhance efficiency. A strong LMIS can support better workforce planning, improve TVET programs, and contribute to economic development.

6.2 Strengthening Coordination Mechanism with Public and Private Sector Providers

Strengthening coordination mechanisms between public and private sector providers is essential for enhancing the relevance and effectiveness of TVET systems in Myanmar. Key strategies include establishing PPPs, creating industry advisory boards, and enhancing governance structures to ensure clear roles and responsibilities. Promoting work-based learning opportunities, such as internships and apprenticeships, and aligning incentives for private sector participation through tax breaks and recognition can further drive collaboration. Leveraging technology, such as digital platforms and labour market information systems (LMIS), facilitates communication and data sharing, while capacity-building initiatives and cultural change foster a collaborative environment. Robust monitoring and evaluation frameworks ensure continuous improvement, enabling a coordinated approach that aligns TVET programs with labour market needs, supports economic growth, and empowers Myanmar's workforce.

6.3 Establishing robust monitoring and evaluation frameworks

Establishing robust monitoring and evaluation frameworks will ensure data-driven decision-making and accountability, while inclusive policies should be implemented to improve access for marginalized groups, including women, rural populations, and persons with disabilities. The framework aims to systematically assess institutional performance, training outcomes, and alignment with labour market needs. Drawing from international best practices and local implementation challenges, this identifies key indicators, data collection methods, and institutional arrangements necessary for a functional M&E system in Myanmar's TVET sector.

7 Conclusion

A well-functioning labour market, supported by robust TVET monitoring, is essential for Myanmar's human resource development. This paper has highlighted key labour market trends, challenges, and opportunities, emphasizing the role of TVET in bridging skill gaps and enhancing employability. Strengthening TVET systems through data-driven policies, industry collaboration, and inclusive training programs can lead to a more dynamic workforce aligned with economic demands. Moving forward, a multi-stakeholder approach involving the government, private sector, and educational institutions is crucial for sustainable workforce development. By improving labour market analysis and TVET monitoring mechanisms, Myanmar can foster a more resilient and skilled workforce, driving economic growth and social progress.

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Karin Langenkamp and Markus Linten

How to Navigate the Data Jungle and Report Mountains: Guidance for Vocational Education and Training

Education reports such as "Education in Germany", "Trends in Continuing Education", and the "Data Report on Vocational Education and Training" provide essential information for policy, practice and research. They use meaningful indicators and promote the visibility of scientific findings. This article presents key publications in vocational education and training reporting and discusses open access as a strategy for improved dissemination. The BIBB's VET Repository is introduced as a transfer tool and open-access database, hosting a wide range of indexed and searchable publications.

1 Visibility and transparency of research results

The path from the research idea to the publication of the results can be described as a research cycle.[1] This process begins with literature and data research, continues with the investigation, and ends with the publication of the results. The visibility and transparency of research results are essential in order to avoid duplication, promote innovation and support transfer into practice and policy.

One example of an institution that actively shapes this transfer is the Institute for Employment Research (IAB). According to Section 283 of the German Social Code, Book III (SGB III), the IAB is obliged to make its research results publicly available. The resulting knowledge transfer is not a matter of course but requires a strategically organised knowledge management process that includes both target-group-oriented preparation and dialogue with practitioners.

The German Council of Science and Humanities[2] emphasised in its position paper on science communication (2021) that science should not only inform but also facilitate dialogue, offer solutions to problems, and raise social awareness. To this end, research results must be made available in a transparent and open manner.

An essential component of this transparency is the open access principle. Open access refers to free and legally unrestricted access to scientific publications. This approach

1 This article was translated with the help of AI. DeepL 01.08.2025.

2 The German Council of Science and Humanities advises the German Federal Government and the governments of the federal states on the content and structural development of universities, science and research. One of its tasks is to draw up recommendations for research institutions as part of evaluations. The BIBB, as a federal departmental research institution, was last evaluated by the German Council of Science and Humanities in 2025.

was established in 2002 in the Budapest Open Access Initiative and in 2003 in the Berlin Declaration. Open access facilitates rapid access to research results and ensures greater visibility for scientific work (Swan 2010).

Open science goes beyond open access: the research process and the resulting research data should also be made openly available as far as possible. This promotes the traceability of scientific work and improves the exchange of information between research, practice and society.

2 Fundamental works on educational reporting in vocational education and training

2.1 Vocational Training Report

The Federal Government's Vocational Training Report has been published for almost 50 years. The first report appeared in 1977, comprising 76 pages, and was published by the former Federal Ministry of Education and Science. In accordance with Section 86 of the Vocational Training Act (see BBiG), the Federal Ministry of Education and Research (BMBF) is responsible for continuously monitoring developments in vocational training and submitting a report – the Vocational Training Report – to the Federal Government by 15 May each year. If the availability of training places is at risk, proposals must be formulated in the report (see BBiG, Section 86).

According to the publisher, the Vocational Training Report describes the key developments on the training market each year. It serves as a basis for discussion for political decisions by those involved in vocational training and the general public. In addition to statistical analyses of vocational training in Germany, the report includes vocational training policy assessments of key developments and a tabular summary of corresponding measures and initiatives by the Federal Government in the field of vocational training.

2.2 Data Report on the vocational training report

The independent Data Report on the Federal Government's annual vocational training report was published for the first time in April 2009. In the years prior to 2009, the Data Report was published under the title "Part II of the BMBF Vocational Training Report". Since then, this standard work has been published with comprehensive information and analyses on the development of initial and continuing vocational training in Germany, which is also placed in an international context. The frequently cited anthology serves as a basis for political decisions with regard to any undesirable developments on the training place market. It is published by the Federal Institute for Vocational Education and Training. Each year, a different topic of interest is addressed; in 2023, this was "Innovations in vocational education and training through programmes", in the 550-page Data Report for 2024, it was "Vocational education and training in the socio-ecological transformation" and in 2025 it was "Immigration Society".

The Data Report is divided into four main topics:

A. Indicators for vocational training
B. Indicators for continuing vocational training
C. Focus topic
D. Monitoring the internationalisation of vocational education and training.

When designing and structuring the Data Report for the vocational training report, care was taken from the outset to ensure that the reporting was based on appropriate indicators (see Friedrich/Krekel 2010).

> "Indicators (indicator: Latin indicare, "to indicate") are measures (absolute values or ratios) that can be used to make certain facts and current circumstances in vocational education and training (actual values) measurable (operationalised) and to show developments over time […] Contrasting the measured values and existing variables with normative, social values or politically-defined targets (target values) reveals (political) needs for action and can be used as a basis for shaping vocational education and training (policy advice)" (Friedrich/Krekel 2010, p. 27).

The Data Report has been available to the public for several years as an open access publication under a Creative Commons licence.

2.3 National Education Report "Education in Germany"

Since 2006, the indicator-based report "Education in Germany" has been published every two years with the aim of providing an overview of the entire German education system: from elementary education to continuing education in adulthood.

The content of the education report is produced under the auspices of the DIPF | Leibniz Institute for Research and Education in Mathematics and Science under the leadership of an interdisciplinary group of authors from various institutions.

The topic of "vocational training" is covered in Chapter E of the current 2024 edition (as it was in 2022); "vocational education" is also a key topic in the current edition. The education report, which is over 400 pages long, is freely available in open access.

2.4 Education at a glance

The Organization for Economic Cooperation and Development (OECD) has been publishing the publication "Education at a Glance (Bildung auf einen Blick)" for almost 30 years, and it is a compilation of comparative international education indicators across the entire education system. It outlines the state of education systems in the 38 OECD member countries as well as in some accession and partner countries. Against the backdrop of equal opportunities, the current edition (2024) focuses on the extent to which educational pathways are influenced by factors such as gender, socio-economic status, country of birth and regional location. The report, which is over 500 pages long, is available as an open access publication.

2.5 DGB Training Report

The annual training report published by the Youth and Youth Policy Department of the German Trade Union Confederation (DGB) can also be included under vocational training reporting. The report is a de facto seismograph for the training situation in Germany and also an important indicator of trainee satisfaction with training; it thus also serves to ensure the quality of vocational training.

According to its own statement, the training report “gives young people a voice and highlights the weaknesses in the dual training system”. The main topics in the 2024 report are trainers and training methods. The DGB Youth, the independent youth organisation of the DGB, surveyed over 10,000 trainees nationwide from the 25 most frequently chosen training occupations in the dual system.

The training report is available free of charge as an online publication on the internet (without a Creative Commons licence).

2.6 Further examples

The list of publications on education reporting that are relevant to vocational training practice and research is long. The following are particularly noteworthy:

- the National Education Panel (NEPS) as the “largest long-term education study in Germany”, which “accompanies the skills development and educational trajectories of a total of over 70,000 participants in seven starting cohorts” (NEPS-Netzwerk 2025),
- the “Trends in Continuing Education – DIE Trend Analysis”,
- the publications of ReferNet (“VET in Europe” reports on education policy developments, etc., and special reports on the systems of the countries holding the presidency of the Council of the European Union),
- the country reports of the International Handbook of Vocational Education and Training (IHBB) and
- the relevant youth studies (SINUS Youth Study, SHELL Youth Study, Youth in Germany Trend Study, etc.), which are highly relevant to classic vocational education and training topics such as career guidance and career choice behaviour among young people.

Overall, education reporting serves as a central basis for political decisions, research work and vocational education and training practice, and highlights areas in need of development.

3 Open access in vocational education and training research

The digitisation of publications and their free availability on the internet have been changing the scientific publishing landscape for years. Open access makes specialist publications available free of charge and as free as possible from technical and legal barriers. This promotes the rapid exchange of research results, improves visibility and strengthens knowledge transfer.

The Federal Institute for Vocational Education and Training (BIBB) pursues an open access strategy to facilitate access to research and work results. This strategy supports both scientific progress and transfer into practice and policy.

The VET Repository is a practical example of the implementation of the open access strategy and ensures long-term access to relevant specialist publications.

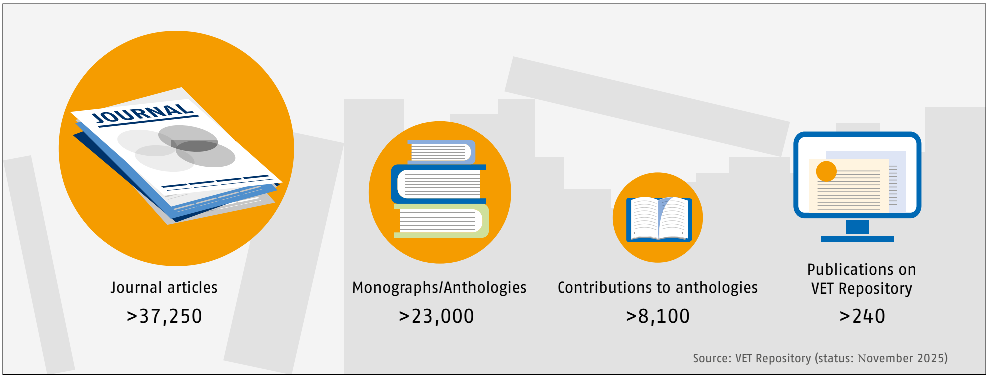
4 VET Repository

The VET Repository of the Federal Institute for Vocational Education and Training (BIBB) is the central publication server and repository for German-language vocational education and training literature. It offers free access to specialist publications on vocational education and training, vocational pedagogy and vocational education and training research published since 1988. The database contains over 68,200 literature references (as of July 2025), of which around 22,000 are linked to full texts, approximately 14,000 of which are permanently stored.

The repository emerged in 2019 from the Vocational Education and Training Literature Database (LDBB), whose holdings were taken over. The specialist literature has been and continues to be systematically indexed using the Vocational Education and Training Thesaurus. Over 54 percent of the references are journal articles, and around 34 percent are monographs (see figure 1). The main topics are:

Dual system, vocational education and training system; training place market and employment system; vocational and qualification research; social science and economic foundations of vocational education and training; design and organisation of vocational education and training; workplace and school-based learning, education personnel, trainees; digitisation in vocational education and training, Industry 4.0; international vocational education and training, international cooperation in vocational education and training; transitions, educational behaviour and pathways.

Figure 1: Document types in the VET Repository



Source: Own elaboration

A particular added value is the permanent availability of the publications, which reduces the risk of dead links and improves citability. This makes it easier for researchers, students, policymakers and practitioners to use the specialist literature in the long term. In addition, the repository offers comprehensive search options and further processing functions:

- The VET Repository database is based on a discovery system. “It enables simultaneous searches of multiple data sources. At the BIBB, this means that the holdings of BIBB's specialised scientific library can be included in the search.
- The database is intuitive to use. Even entering a relatively simple search term can provide a good starting point for a search. An assistant for suggestions (similar to search engines such as Google) provides suitable title recommendations after the first few letters are entered. If a search does not return any results, suggestions for alternative search terms are provided” (Langenkamp/Woll 2022).
- An advanced search with logical operators (AND, OR, NOT) is available for complex searches.
- Search results can be filtered retrospectively by document type, time period and other criteria using faceting.
- It is possible to export hits to literature management and word processing programmes. A link to the BIBB employee profiles ensures that references are automatically fed into the BIBB homepage (cf. Langenkamp/Woll 2022).

Another key aspect of providing digital literature concerns the difference between bibliographic databases and full-text databases. While bibliographic databases “generally use elaborate methods for formal bibliographic description [information on author, title, year, publisher, length, etc.] and content indexing” (Stock 2007, p. 157) and primarily refer to literature, full-text databases offer direct access to the complete text of the publication.

In the repository, this could be a monograph comprising several hundred pages, an article from a specialist journal, or a contribution to a collection. Storing the full text enables searches not only via metadata such as titles, keywords or abstracts, but also across the entire text content. Every single word – with the exception of so-called stop words such as articles or conjunctions – is searched (Linten/Rauss genannt Kaiser 2022).

This comprehensive search option means that a simple search in a full-text database generates significantly more hits than a pure metadata search. For example, the “Data Report on Vocational Training 2021” contains over 200,000 words, while an average data record in a literature database contains only around 200 words. This opens up considerably expanded research potential for researchers, teachers and students.

The repository also serves as a publication platform for open access publications and enables both BIBB staff and external researchers to publish their work for the first time or as a second publication. It is therefore a central component of open science and promotes the transfer of research results to politics, practice and society (cf. Langenkamp/Woll 2022).

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Chapter 2:
Data-Driven Policy Making in TVET

Minkyoo Kim

▶ The Role of Empirical Research in Policy Design: A Systematic Review of 10 Years of Data on Korea's Apprenticeship

This study systematically reviews ten years of empirical research on Korea's Apprenticeship System to evaluate the effectiveness and limitations of data-driven policy design. Introduced in 2014, Korea's apprenticeship system adopted a hybrid model through compressed, government-led institutionalization, despite lacking a strong sociocultural foundation. The study identifies key policy outcomes, including rapid quantitative expansion, employer-led implementation, and sectoral diversification. However, challenges remain in qualitative areas such as training quality, retention, and employment outcomes. It concludes that while Korea's experience offers policy insights for other nations, sustaining growth will require stronger data infrastructures, inclusive governance, and long-term outcome evaluation.

1 Introduction

In response to rising youth unemployment and the widening mismatch between vocational education and employment, countries around the world are increasingly adopting apprenticeship systems to cultivate skilled labour.[1] Following this trend, Korea has also formally introduced its apprenticeship approach in 2014. Korea's apprenticeship system is considered to have developed a unique structure as hybrid apprenticeship model[2] from an international comparative perspective. Although a fully developed institutional foundation was not yet in place, Korea pursued the design and implementation of the system simultaneously through a government-led strategy characterised by compressed growth.

The Korean-style apprenticeship system has, from its inception, relied on empirical data gathered through field surveys, pilot projects, and policy evaluations to diagnose institutional challenges and pursue either incremental or innovative reforms. This experience in data-driven policy management is regarded as an important case demonstrating that the introduction and expansion of an apprenticeship system is possible even in the absence of a strong sociocultural foundation. In this context, Korea's experience of institutionalizing an apprenticeship system in a short period of time without longstanding traditions or broad

1 The author acknowledges the use of OpenAI's ChatGPT (Version 4.0, January 2025) in the translation process. All content has been subsequently verified and edited by the author.

2 This reflects Korea's selective integration of key elements from major advanced countries, such as the U.S. education system, the U.K.'s National Vocational Qualifications (NVQs), and Germany's dual system, resulting in a so-called hybrid apprenticeship model (Jacobs 2018, p. 120).

social consensus – and of linking that institutionalization to tangible policy improvements – offers highly practical lessons and policy references for countries starting from similar points of departure.

This study's primary objective is to identify the key factors influencing policy outcomes and to assess the effectiveness and limitations of data-driven policy design. Through this analysis, the study seeks to empirically examine how the apprenticeship system has been developed and institutionalized within the Korean context, providing insights for future policy advancement and system development.

2 Methodology

This study conducted a meta-review of domestic quantitative empirical research from the past decade, focusing on the institutionalization of Korea's Apprenticeship. Its primary goal was to identify the key factors influencing policy outcomes and to suggest directions for policy design based on empirical evidence. Rather than emphasizing the statistical significance or effect sizes of individual studies, the analysis synthesized major research trends, study populations, variable structures, and policy implications by identifying common patterns and substantive themes across research designs and analytical perspectives. The literature was collected from major Korean academic databases, including Research Information Sharing Service (RISS), DataBase Periodical Information Academic (DBpia), Korean studies Information Service System (KISS), National Discovery for Science Leaders (NDSL), and the Korea Research Institute for Vocational Education and Training repository (KRIVET repository). The search covered academic articles, policy reports, and theses published between January 2014 and January 2024.

3 Results and Discussion

This chapter analyses the current status and challenges of Korea's Apprenticeship through two main lenses: quantitative expansion and qualitative improvement.

3.1 Quantitative Expansion

3.1.1 Expanding the Number of Participants

Since its official launch in 2014, Korea's Apprenticeship has achieved remarkable growth in participant numbers over a relatively short period. Starting with 3,154 learner-workers, the cumulative total surpassed 138,000 by May 2023, with more than 30,000 individuals actively participating in the system. This rapid expansion reflects significant institutional progress in adapting apprenticeship systems – similar to those in Germany, the UK, and the US – to the Korean context. The system has also gained recognition as a viable policy alternative to address the limitations of both secondary and tertiary vocational education in cultivating skilled labour.

To expand participation and advance the Apprenticeship, the Korean government has developed a multi-layered data collection and management system that links administrative databases with employment insurance records and conducts project-based field surveys. This data foundation has supported a range of empirical studies, including the development of post-learning models (Son et al. 2021). Nevertheless, over the past three years, system growth has plateaued, with participation rates at junior colleges and universities remaining below expectations.

3.1.2 Expanding the Number of Participating Companies

The Apprenticeship in Korea displays a strong employer-centered orientation in both its design and operation[3]. While the employer-centered operation of Korea's Apprenticeship has helped enhance its practical feasibility, it also carries structural risks of excessive compromise in the quality and content of training. As a result, concerns have emerged that companies may seek to shorten training durations or relax selection criteria for participating firms, raising the risk that the system may shift toward a short-term operational model (Kang et al. 2016).

To ensure the sustainable and substantial expansion of corporate participation in the Apprenticeship, it is necessary to establish qualitative standards for training content and operational conditions, and to introduce a certification and incentive system based on these standards (Kim/Song 2023). In addition, building a real-time feedback system that monitors both quantitative and qualitative aspects of corporate training practices would help prevent distortions driven by short-term operational focus and institutionalize regular consultation between companies and policymakers (Park et al. 2020).

3.1.3 Expanding into new Sectors

From the early stages of introducing the Apprenticeship, Korea referenced European apprenticeship models in designing its framework. In particular, as labour shortages became pronounced in Korea's traditional manufacturing and "root industries" at the time, similarities between these sectors and Germany's industrial apprenticeship fields were emphasized. Consequently, companies initially operated apprenticeship programs primarily in industrial fields such as machinery, information technology, and electrical and electronic engineering[4]. However, by 2023, there has been a gradual expansion into non-industrial

3 According to the "Survey on Participants, Graduates, and Workplace Trainers in the Apprenticeship" (Jeon et al. 2016), most participants – including learner-workers, workplace trainers, and HRD officers – entered the programme based on encouragement from their employers. Specifically, 84.4 percent of learner-workers reported joining the programme following employer recommendation, while 54.0 percent of workplace trainers and 67.5 percent of HRD managers indicated similar motivations (Moon et al. 2023).

4 In fact, as of 2014, companies participating in the system were heavily concentrated in industrial sectors, with machinery (robotics) accounting for 41.1 percent and information technology for 19.1 percent of all participating firms (HRDK 2015).

sectors such as business management, accounting, and office work, reflecting an ongoing diversification of fields covered by the Apprenticeship[5].

3.2 Qualitative Expansion

3.2.1 Maintaining Retention and Completion Rates

In practice, rising dropout rates were seen as signs of inefficiency in the use of public funds (Jeon et al. 2016b), leading to an intensified focus on formal compliance across the system (Park et al. 2020). However, this approach structurally conflicted with the original purpose of the Apprenticeship, which aimed to deliver long-term, practice-based, company-specific training. As a result, friction with participating companies became increasingly common. Notably, Jeon et al. (2016a) highlighted the formalization of programme operations as a major management issue. Instead of prioritizing substantive learning, administrative responses – such as securing internal and external assessment rates and meeting monitoring targets – were emphasized, suggesting a shift toward a more formalistic, compliance-driven management model.

To address rising dropout rates and the increasing tendency toward formalistic programme management, a more sophisticated, data-driven approach to policy design is needed. Park et al. (2020) proposed developing an early warning system to predict dropout risks in advance by identifying high-risk groups based on factors such as age, major, company size, and attendance patterns, and offering tailored counseling and support programs.

3.2.2 Strengthening Employment Outcomes such as Retention Rates

Recent domestic research on the Apprenticeship in Korea has moved beyond simply tracking participant growth to focus on identifying who benefits from the system, under what conditions, and in which contexts. While data-driven research highlights the potential of the apprenticeship system, its actual effectiveness remains an open question. Criticism persists, particularly because, despite the relatively high costs compared to other vocational training programs, clear empirical evidence for employment outcomes – such as job placement rates and employment retention – has not yet been fully established[6]. This points to the need for more refined empirical analysis to assess whether the Apprenticeship is not only achieving short-term quantitative growth but also supporting structural employment stability and sustainable transitions into the labour market.

5 Korea's Apprenticeship System in 2024 shows a more diversified occupational distribution: machinery accounted for 21.1 percent electrical and electronics for 14.8 percent business, accounting, and administration for 11.1 percent information and communication for 10.9 percent and materials for 6.1 percent (HRDK 2025).

6 As of May 2023, Korea's youth unemployment rate (ages 15–29) stood at 5.9 percent with an employment rate of 46.5 percent (Statistics Korea 2024). However, despite these quantitative gains, there remains substantial room for improvement in the quality of employment. According to Statistics Korea, nearly one million employed youths are engaged in temporary jobs with contract terms between one month and one year. Moreover, it takes an average of 10.4 months for graduates to secure their first job, while their average tenure at that job is only 6.6 months (Statistics Korea 2023).

4 Conclusion

4.1 Reflections on 10 Years of Korea's Apprenticeship: Achievements and Remaining Challenges in Data-Driven Monitoring and Evaluation

Korea's Apprenticeship has achieved notable quantitative progress over its first decade, including increases in both the number of participating learner-workers and partner companies (Kim 2019; Ahn 2024). From its inception, the system has relied on empirical data collected through systematic surveys, pilot programs, and policy evaluations. A particularly notable achievement is the development of a multi-layered data infrastructure that links administrative databases, employment insurance records, and regular nationwide surveys, enabling comprehensive policy assessments and the tracking of graduates' employment paths even after programme completion. These experiences may offer practical lessons for other countries considering the introduction of apprenticeship models, emphasizing the value of evidence-based policymaking and data-driven monitoring.

4.2 Can Data-Driven Policy be Generalized to Other Countries?

Comparative analysis of international cases continues to serve as an important reference in the design of apprenticeship systems. Accordingly, the international expansion of apprenticeship systems should focus not on simply transplanting existing models but on pursuing contextualized designs and gradual adaptations that reflect each country's unique sociocultural, institutional, and policy environments. Rather than replicating European structures as a whole, most countries might be recommended to selectively combine different institutional elements. Thus, they should pursue strategic designs grounded in their own institutional capacities and practical feasibility while embedding empirical evaluation and feedback structures to assess the transferability and sustainability of apprenticeship systems.

Policy research on expanding apprenticeship systems must reflect each country's specific context; otherwise, an excessive focus on short-term outcomes risks undermining the system's long-term sustainability. Data-driven research plays a crucial role in mitigating such biases by quantitatively verifying policy effectiveness and countering the tendency toward short-term, output-oriented policy management. In addition, by providing a foundation for analyzing long-term trends, data-driven research enables the evaluation of system sustainability and supports the development of balanced, context-sensitive policy designs.

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Evidence-Based Professional and Higher Education Policy through Data Reporting and Data Science

The article analyses the application of data management in Vocational and Higher Education, using the case of the National Industrial Learning Service (SENAI). SENAI has invested in information systems and data dashboards to improve the management of its courses and align them with market demands. The *data-driven* approach, which involves planning, implementation, monitoring and evaluation, is essential for optimizing performance and achieving strategic objectives in Vocational and Higher Education. The use of data dashboards enables comprehensive analysis and strengthens collaboration between SENAI's National Department and its 27 Regional Departments distributed throughout Brazil, making management more responsive and effective.

1 Introduction

The *data-driven* approach (ADD) has established itself as a fundamental approach for organizations seeking to optimize their performance and achieve their strategic objectives. In the context of Vocational and Higher Education, ADD is particularly relevant, given the need to align the courses on offer with the dynamic demands of the job market and to guarantee the employability of graduates.

According to the Organization for Economic Cooperation and Development (OECD 2007), ADD is a management cycle that involves planning, implementing, monitoring and evaluating actions, with a focus on producing positive results and impacts for society. This approach presupposes the definition of clear objectives, the use of performance indicators, the systematic monitoring of results and the accountability of managers.

In this article, we propose to analyze the application of ADD in Vocational and Higher Education, using the case of the National Industrial Learning Service (SENAI). SENAI, the largest private vocational and higher education network in Latin America, has been investing in information systems and data panels since 2013 to improve the management of its courses and make them more responsive to market needs.

In a constantly evolving industrial scenario, driven by technological advances, changes in professions and the restructuring of production chains, the ability to make decisions based on reliable data stands out as a strategic differentiator, according to Segatto 2017.

In this context, the creation of data dashboards has emerged as an innovative solution for converting information into effective actions, as highlighted in OECD 2021. More than simple data repositories, these dashboards function as dynamic decision support systems, allowing indicators to be analyzed by schools, modalities, areas, courses, age groups, gender, municipalities, demands and various other variables. This comprehensive analysis makes the knowledge generated even more strategic for the institution.

In addition, the panels strengthen collaboration between SENAI's National Department and the 27 SENAI Regional Departments throughout the country, speeding up the response to industry demands and planning training offers that are more in line with reality. By consolidating and analyzing data in an integrated way, the National Department can identify regional gaps, help define strategic priorities and guide complementary actions that promote greater equity and impact on training results at the national level.

2 Data-driven Approach in Vocational and Higher Education: current perspectives and methodological challenges[1]

The data-driven approach (DDA) is recognized as fundamental for optimizing performance in Professional and Higher Education, with a conceptual evolution that transcends the traditional linear cycle. Currently, DDA is understood as a management strategy oriented towards results and impacts, integrating evidence-based decision-making, continuous learning and adaptability. This perspective contrasts with views that restrict it to mere performance measurement, with effective implementation depending on an organizational reorientation towards continuous learning and improvement, as pointed out by criticisms of the rigidity of prescriptive models in dynamic contexts.

The contemporary practice of DDA is based on interconnected components, as explained in Table 1: Evolution of the Components of the Data-Driven Approach in Recent Literature.

1 The data in this chapter were prepared with the help of the Gemini language model (Google, 2025, version 2.5 Flash), 09/05/2025.

Table 1: Evolution of the components of the data-driven approach

Component (Original – Based on OECD, 2007/Original Text Section 2)	Component (Current Perspective – Based on Recent Research)
Strategic Planning (Definition of Objectives and Goals)	Evidence-Based Strategic Planning and Theory of Change (Casual analysis, stakeholders, Theory of Change (ToC), cascading outcome, risks/assumptions)
Supply Management (Course Planning)	Supply Management and Adaptive Implementation (GR-informed program/project management cycle, flexibility in execution)
Monitoring and Evaluation (Follow-up with Indicators)	Continuous Monitoring for Learning and Management (Focus on using data for decisions, relevant and manageable indicators (CREAM), feedback loops)
Accountability (Assigning Responsibilities, Accountability)	Evaluation Focused on Effectiveness, Impact and Relevance (Complementary to monitoring, in-depth casual analysis, lessons learned)
	Multidimensional Accountability and Transparency (Balance between control and learning, accountability to various stakeholders, open communication)
	Organizational Learning and Results Culture (Cross-cutting enabling component: leadership, culture, capacity, objectives)

Source: Own elaboration

These components include strategic planning based on evidence and theory of change, continuous monitoring for learning and adaptive management, evaluation focused on effectiveness and impact, accountability and transparency, and organizational learning supported by a culture of results. The effectiveness of ADD emerges from its systemic nature, where each component is related to and influences each other, with data panels being only an integral part of this complex system.

The implementation of ADD in Professional and Higher Education faces significant challenges, especially in the Brazilian scenario. Common obstacles include the lack of engaged leadership, cultural resistance to change, scarcity of resources and technical capacity, difficulties in applying inflexible models, problems with data quality and use, and the lack of political-institutional alignment. In the specific context of professional education, the need for dynamic alignment with the labour market and the complexity of evaluating long-term results and integrated pedagogical approaches are highlighted.

The successful implementation of DDA relies on critical factors such as consistent leadership, stakeholder engagement, strategic clarity, robust institutional capacity, a culture of learning and adaptation, and properly aligned incentives. The effective adoption of ADD is a complex process of organizational transformation, requiring a change in mindsets, routines, and culture, in addition to the mere application of tools.

In the dynamic context of Brazilian Professional and Higher Education, marked by digitalization and the transition to a sustainable economy, SENAI has adopted the ADD approach as a strategic operational framework to adapt its educational offering to market demands, promoting equity and inclusion. This change in focus prioritizes the quality of training, concrete employability results and skills adaptation, and the impact on socioeconomic development, to the detriment of traditional metrics focused on inputs and activities. The viability of ADD at SENAI is supported by an ecosystem of data panels for collecting, processing and visualizing information, allowing objective assessments, informed decision-making and continuous improvement cycles, which signals a cultural evolution towards accountability and a culture of performance, reinforcing SENAI's role as a strategic partner for industry and government by proving its tangible contribution to economic and industrial development.

3 Data infrastructure: dashboards as a management and analysis tool[2]

Data dashboards constitute the primary interface through which SENAI managers, analysts and technical teams' access and interpret a vast volume of operational and strategic information. Far from static reports, these dashboards are dynamic and interactive tools that support ongoing management processes and facilitate the practical application of ADD principles throughout the SENAI network. They represent the technological materialization of the institution's commitment to evidence-informed management.

Fundamental to the power of this system is the integration of two complementary approaches to data analysis: *data reporting* and data *science*.

- *Data Reporting*: this function focuses on answering the question "what is happening?" It involves systematic monitoring of key performance indicators (KPIs), enrollment trends, completion rates, operating costs, among others. *Reporting* is crucial for operational situational awareness, allowing for the rapid identification of deviations from established targets and the monitoring of the overall health of educational operations. Examples include tracking enrollment volume by unit or course or monitoring dropout rates [D_IE].
- *Data Science* (Deep Analysis and Foresight): this function seeks to answer more complex questions such as "why is this happening?" and potentially "what might happen next?" It uses statistical analysis techniques, pattern identification, data segmentation, correlation analysis and, in some cases, predictive modeling. *This approach* allows SENAI to understand the underlying causes of observed trends (for example, the factors that lead to school drop- outs), identify complex relationships between variables (such as the influence of socio-economic profile on student performance) and anticipate future market needs or potential risks (such as future demand for skills linked to green technologies).

2 The data in this chapter were prepared with the help of the Gemini language model (Google, 2025, version 2.5 Flash), 09/05/2025.

The coexistence and integration of these two capabilities within the same dashboard ecosystem generates a powerful synergy. It allows users to move fluidly from observing a phenomenon (for example, an increase in dropout in a specific course, identified via *reporting* in the Strategic Indicators dashboard (D_IE)) to investigating its causes (analyzing the correlation of this dropout with demographic or performance data from dashboards such as Integrative Solution, Generations (D_GE), People with Disabilities (D_PD) or Race and Ethnicity, using the most in-depth analysis tools). This ability to go from "what" to "why" within the same platform speeds up the identification of problems and the formulation of targeted interventions. This approach demonstrates SENAI's capacity in data governance and *analytics*, positioning the institution beyond the basic reporting of past information, using data as a strategic asset to generate knowledge, support decisions and even gain competitive advantages in the Vocational and Higher Education scenario, anticipating trends and adapting proactively.

4 SENAI's data dashboard ecosystem: a detailed overview

SENAI's analytical capacity is underpinned by a diverse set of data dashboards, each designed to provide specific insights that together offer a complete picture for the *data-driven* approach. The following table summarizes the main dashboards and their primary functions.

Table 2: Overview of SENAI's main *data* dashboards for the *data-driven* approach

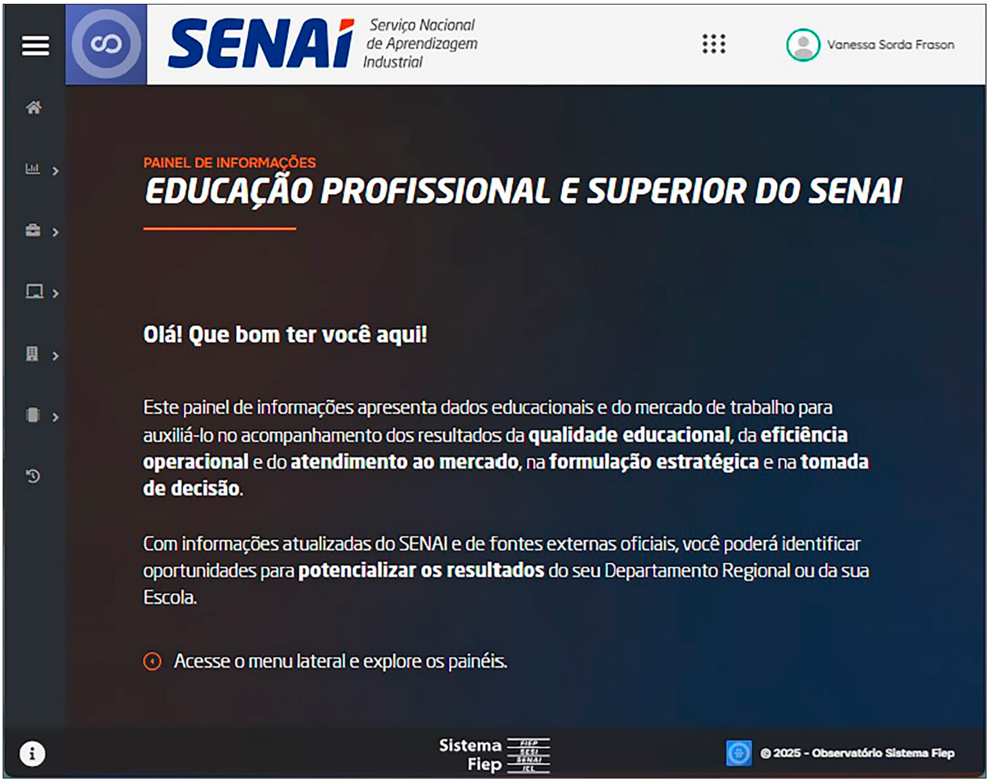
Panel Name	ID (Reference)	Primary Function	Key Data/Metrics	Contribution to the DDA
Integrative Solution	D_SI	Overview of educational production and student profile by location.	Enrollment, graduates, demographic profile (age, gender, etc.), previous education, by course, unit, municipality, state.	Understanding of the scale, reach and profile of the public served; basis for regionalized planning.
Strategic Indicators	D_IE	Monitoring of institutional key performance.	Academic performance, dropout rates, cost per student/course, alumni analysis (initial employability, satisfaction).	Monitoring of strategic goals; identification of performance and efficiency GAPs; evaluation of the initial effectiveness of the programs.
Generations	D_GE	Analysis focused on age cuts.	Participation, performance and results by age group, crossed with data from other panels (e.g., D_SI, D_IE).	Informs strategies to serve different generations in the labour market; promotes generational equity.

Panel Name	ID (Reference)	Primary Function	Key Data/Metrics	Contribution to the DDA
People with Disabilities	D_PD	Analysis focused on the inclusion of people with disabilities.	Participation, performance and results of students with disabilities, cross-referenced with data from other panels.	Monitors accessibility and equity; subsidizes actions for effective inclusion and social relevance.
Race and Ethnicity	D_RE	Analysis focused on racial and ethnic equity.	Participation, performance, and results by self-reported racial/ethnic group, cross-referenced with data from other panels.	Monitors racial equity; informs policies and practices to tackle inequalities and promotes diversity.
Demand x Supply (includes Priority Courses, Supply x Demand, O x D x Free.)	D_DO	Analysis of the alignment between course supply and market demand; management of gratuity.	Comparison of vacancies offered vs. identified demand, prioritization of courses, allocation of free vacancies, market data (vacancies, salaries).	Guides the expansion/reduction of courses; prioritizes investments; aligns supply with economic needs; optimizes the use of free resources.
Industrial Work Map	D_MTI	Mapping of current and future needs for labour and skills in the industry, with a focus on digital transformation and green transition.	Occupational demands by sector/region, emerging skills (digital, green), employment projections, technological trends.	Informs curriculum development; anticipates future demands; ensures the long-term relevance of the training.
Agroindustry Market	D_MA	Specific analysis of the demands of the labour market in the agribusiness.	Occupational demands, specific competencies (including AgTech), regional trends in the agro-industrial sector.	Ensures the relevance of the offer for a strategic sector; allows customization of programs for the agribusiness.
Apprenticeship	D_AP	Monitoring of industrial learning outcomes.	Apprentice hiring rate, number and profile of hiring companies, hiring sectors, possibly satisfaction of companies/ apprentices.	Evaluates the effectiveness of the learning modality; strengthens partnerships with industry; improves the school-to-work transition.

Source: Own elaboration

To illustrate the panels, here are some prints:

Figure 1: Ecosystem Overview



Source: own elaboration by SENAI

Figure 2: Partial view of the menu

Source: own elaboration by SENAI

The function of each of these panels in the context of SENAI's ADD methodology is detailed below.

- Integrating Solution (D_SI):
  This dashboard acts as the fundamental layer of information on SENAI's educational output. It provides a comprehensive and geographically segmented view of enrollments, completers and the detailed profile of students (age, gender, previous schooling, etc.) by course, school, municipality and state. Its main function is to offer a quantitative and demographic portrait of educational activities, answering the basic questions of "who", "what", "where", and "when". This geographical granularity is essential, as it allows SENAI to understand significant regional variations in both the profile of students and the demand for specific courses. This understanding makes it possible to develop more assertive and customized regional strategies, rather than a one-size-fits-all approach, optimizing the allocation of resources and communication with local audiences.

- Strategic Indicators (D_IE):
  Acting as the central dashboard for institutional performance, D_IE monitors key performance indicators (KPIs) aligned with SENAI's strategic objectives. This includes student

academic performance metrics, drop-out rates (a critical indicator of efficiency and engagement), costs per student or per course (essential for efficiency analysis) and, crucially, the D_IE graduate analysis. The latter tracks graduates' labour market outcomes, such as initial employability rates and, potentially, satisfaction levels, providing vital feedback on the effectiveness of programs. The explicit inclusion of D_IE 'graduate analysis' demonstrates a commitment to measuring long-term results (effectiveness) and closing the feedback loop: understanding the success of graduates in the real world feeds back into the planning and continuous improvement of programs, a pillar of the DDA.

- Equity Panels (Generations D_GE, People with Disabilities D_PD, Race and Ethnicity D_RE):
  This set of panels (D_GE, D_PD, D_RE) is dedicated to the disaggregated analysis of educational data from the perspective of equity and inclusion. They make it possible to examine the participation, performance (using D_IE data filtered by these dimensions) and results of students belonging to different demographic groups: age cut-offs (D_GE), people with disabilities (D_PD) and various racial and ethnic groups. These dashboards are key to ensuring that SENAI's actions are aligned not only with industrial demands but also with broader social objectives of promoting equal opportunities. By going beyond the general average, these panels enable SENAI to identify specific barriers or success factors for diverse student populations. For example, the detection of significantly lower completion rates for a particular ethnic group can trigger investigations into the causes (financial, pedagogical, cultural barriers) and the development of affirmative action or customized support services. The existence and systematic use of these dashboards (D_GE, D_PD, D_RE) evidences an institutional commitment to social responsibility, allowing SENAI to monitor its progress towards a more inclusive education system, which in turn increases its social relevance and its ability to serve Brazil's diverse workforce.

- Demand-Supply Alignment (Demand x Supply D_DO, Industrial Labor Map D_MTI):
  This cluster of analytical tools is central to SENAI's relevance strategy, focusing on the alignment between course offerings and labor market needs. The D_DO dashboard compares SENAI's current and planned course capacity with identified demand signals (from various sources, such as sector surveys, job vacancy analysis, economic data). It includes specific visualizations on courses considered a priority and on how free places (gratuity) are allocated in relation to this D_DO demand. In addition, D_MTI offers a broader and more forward-looking mapping of industrial labour demand. It details, with geographical and sectoral sections, the growing occupations, the skills required (current and future) and the emerging professional profiles, with an explicit emphasis on the needs generated by the digital transformation (artificial intelligence, cybersecurity, data analysis, internet of things) and the green transition (renewable energies, circular economy, sustainable processes).
  The synergistic combination of D_DO and D_MTI allows SENAI to carry out gap *analysis*. The institution can identify not only current mismatches between supply and demand but, crucially, anticipate future skills shortages, especially in areas of high growth and

technological transformation. This foresight capability is vital if SENAI is to develop or adapt curricula and programs *before* shortages of skilled labour become a bottleneck for industry, acting proactively rather than just reactively. In addition, the specific functionality within D_DO that connects demand analysis to the allocation of free places (D_DO) illustrates a strategic use of resources. By giving priority to free courses aligned with the greatest industrial demands (identified via D_DO and D_MTI), SENAI maximizes the impact of these subsidies, promoting employability and, at the same time, meeting the needs of Brazilian industry.

- Agroindustry Market (D_MA):
  Recognizing the strategic importance and unique characteristics of the Brazilian agro-industrial sector, SENAI has a dedicated panel, D_MA, which provides specific market intelligence for this area. This panel details the particular occupational demands of the agro-industry, the technical and technological skills required (including those related to precision agriculture, biotechnology, sustainable resource management and other AgTech technologies), as well as regional variations and trends within this vast sector. The existence of this specialized panel allows SENAI to go beyond general industrial analyses (provided by D_MTI) and develop highly customized training programs for the specific needs of the agro-industry. This includes everything from courses on operating drones to monitor crops to maintaining automated irrigation systems or sustainable farming practices, ensuring greater relevance and impact of SENAI's work in this vital sector for the Brazilian economy.

- Industrial Apprenticeship (D_AP):
  Industrial apprenticeships are central to SENAI's offer, characterised by the strong integration of theoretical training and practical experience in the workplace. The D_AP dashboard is dedicated to monitoring the results and effectiveness of this modality. It tracks crucial metrics such as the hiring rates of apprentices after the end of the programme, the number and profile of companies that hire apprentices (by size, sector, region) and, potentially, satisfaction indicators for both apprentices and partner companies. By analyzing which companies are the most active hiring partners and understanding their needs and satisfaction levels, SENAI can strengthen these partnerships, identify opportunities to improve industrial apprenticeship programs to better meet market expectations and refine its placement strategies. This strengthens the crucial transition from school to work. When high hiring rates, evidenced in the D_AP, are correlated with training in high-demand areas identified in the D_DO and D_MTI panels, SENAI obtains proof of the effectiveness of its market-aligned training model. This creates a clear, data-based narrative: SENAI identifies the needs of the industrial market, offers relevant training and its graduates are absorbed by the job market, validating the entire ADD cycle.

5 Data-driven decision-making: from analysis to supply optimization

The implementation of the *data-driven* approach at SENAI, leveraged by data dashboards, is not limited to the visualization of information; it translates into a cyclical and dynamic process that transforms data into concrete actions to optimize the educational offer. This decision-making flow can be described in interconnected stages:

- Data collection and consolidation: information from SENAI's various operational systems (academic, financial, industry relations, etc.) is continuously collected, processed and consolidated, feeding the different data dashboards;
- Monitoring and analysis: managers and technical teams use dashboards for two main purposes: routine monitoring of indicators and trends (*reporting* function) and more in-depth analysis to investigate causes, identify patterns and explore relationships between variables (*data science* function);
- Knowledge generation (*insights*): data analysis reveals critical findings that inform decision-making. These can include:
  - *Demand gaps:* identification of areas where labour market demand significantly exceeds SENAI's current offer of courses, with special attention to digital and green skills;
  - *Overprovision or underperformance:* detection of courses with low demand, high dropout rates (D_IE), or low employability rates for graduates (D_AP, D_IE);
  - *Need to update the curriculum:* evidence, from the comparison between the content of the courses and the emerging competencies mapped, that the curricula need to be revised to maintain relevance;
  - *Performance and equity issues*: identification of high dropout rates or low academic performance (D_IE), which may be concentrated in specific groups of students, signaling the need for support or pedagogical interventions;
  - *Equity gaps:* evidence of under-representation or under-performance of certain demographic groups in accessing or completing courses;
  - *Operational inefficiencies:* identification of programs that do not translate into satisfactory results (employability, completion), indicating possible operational adjustments.
- Informing strategic and operational decisions: the knowledge generated from data analysis directly supports decisions at different levels:
  - Strategic Decisions (Portfolio Management): these include defining the launch of new courses (especially to meet the demands of the digital transformation and green transition, based on D_MTI and D_MA), discontinuing obsolete or low-impact courses, carrying out in-depth curriculum reviews, targeting investments in new educational technologies and infrastructure, and establishing strategic priorities for the allocation of free places;

- Operational Decisions (Resource Allocation): these include planning class offerings, allocating instructors and laboratories, adjusting class sizes, targeting efforts to attract students, implementing specific student support measures (reported by D_IE, D_GE, D_PD, D_RE), and managing regional budgets based on performance and demand indicators.

To illustrate this process, consider a hypothetical scenario focused on the green transition: the D_MTI panel detects a growing and projected demand for “Photovoltaic Solar Panel Installation Technicians” in a given region. The D_DO panel confirms that SENAI’s current offer for this occupation is non-existent or very limited. Cross- referencing with D_SI shows that young people in the region are interested in related technical areas (electrotechnics, for example). The D_IE may indicate idle capacity in existing electrical workshops that could be adapted. Based on this confluence of data, the strategic decision could be to launch a new course or specialization in photovoltaic solar energy. Subsequent operational decisions would include: allocating free places for this priority course (D_DO), investing in adapting the infrastructure and training instructors, targeting marketing actions at the audience identified in D_SI, and then closely monitoring enrollment, student performance (D_IE) and the rate of professional insertion of graduates (D_AP, D_IE).

This example demonstrates how the decision-making process transforms descriptive information, scattered across multiple panels, into prescriptive and coordinated actions. Data is not just a record of the past but an active catalyst for adaptation and continuous improvement of the educational offer. The ability to quickly translate market signals – especially the forward-looking ones captured by D_MTI – into concrete educational programs gives SENAI operational agility. This agility represents a significant competitive advantage, allowing the institution to maintain its relevance in an increasingly dynamic and demanding Vocational and Higher Education scenario.

6 Impact assessment: measuring the gains of the *data-driven* approach

The adoption of the *data-driven* approach methodology, driven by the data dashboard ecosystem, generates measurable and positive impacts on SENAI’s performance in three crucial dimensions: effectiveness, efficiency and relevance.

- Effectiveness:
  The effectiveness of Vocational and Higher Education essentially measures how well it prepares individuals for the job market and meets the needs of industry. ADD improves SENAI’s effectiveness in several ways. Firstly, the strong alignment between course offerings and real and future market demands, made possible by the continuous analysis of the D_DO, D_MTI and D_MA panels, ensures that students develop skills that are, in fact, valued by employers. This translates directly into higher employability rates and

faster, smoother transitions from school to work, results that can be monitored through the analysis of graduates and apprenticeship placement data.
Secondly, the relevance of the skills taught is ensured by the constant updating of curricula, informed by market intelligence on new technologies and professional requirements. However, effectiveness depends not only on the relevance of the content, but also on the ability of students to successfully complete their training. By using the D_IE, D_GE, D_PD and D_RE panels to identify and address factors that lead to dropout or low performance, SENAI increases completion rates. This means that more students actually acquire the necessary skills, expanding the pool of professionals prepared to enter the workforce. The combination of aligning market with a focus on student success maximizes the overall effectiveness of the educational intervention.

- Efficiency:
  Efficiency refers to the ability to achieve the desired results with the optimal use of available resources (financial, human, infrastructure). ADD promotes significant efficiency gains. Decisions on resource allocation become more rational and strategic. Investments are primarily directed towards programs that demonstrate high market demand, good student performance (D_IE) and positive employability results (D_IE, D_AP). The management of gratuity, informed by the D_DO panel, exemplifies this optimization, directing subsidies to where they can generate the greatest return in terms of employability and productivity for the industry. In addition to allocation between programs, efficiency is also improved within programs. An analysis of the causes of dropout (D_IE), often associated with socio-economic or pedagogical factors identifiable through equity dashboards, makes it possible to implement targeted interventions to improve retention. Each student who drops out represents an investment of resources that has not resulted in a qualified professional. Therefore, by reducing dropout, SENAI not only improves effectiveness but also increases efficiency, reducing the effective cost per graduate.

- Relevance:
  Relevance, in a context of rapid technological and social change, is the ability of an educational institution to stay connected and responsive to the emerging needs of the economy and society. The ability to quickly identify, through D_MTI and D_MA, the skills demanded by industry allows SENAI to adapt its offer in an agile way, preparing the workforce for the jobs of the future. This agility is crucial if Brazilian industry is to incorporate new technologies and sustainable business models. At the same time, the attention paid to issues of equity and inclusion, monitored through the D_GE, D_PD and D_RE panels, ensures that SENAI also responds to social expectations, promoting opportunities for all segments of the population and contributing to fairer development. Relevance, therefore, is maintained through a dynamic balance, where economic demands are constantly weighed against social responsibilities and the realities of internal performance, all mediated by data analysis. This demonstrated ability to remain relevant to both industry and society, and to prove this relevance through concrete data, strengthens SENAI's legitimacy and role on the national and international stage. It strengthens SENAI's ability

to enter into strategic partnerships and contribute to the debate and the identification of effective paths for a virtuous cycle of continuous improvement and impact.

7 Conclusion: SENAI's quality in vocational education

In summary, SENAI's commitment to the *data-driven* approach methodology, operationalized through an ecosystem of data dashboards (D_SI to D_AP), establishes a powerful engine for the continuous improvement and strategic adaptation of Vocational and Higher Education. The integration of *data reporting* (descriptive monitoring) and *data science* (in-depth, forward-looking analysis) capabilities allows the institution not only to understand its past and present performance but also to anticipate future trends and identify the underlying causes of observed phenomena.

This process forms a virtuous cycle: the data collected feeds multifaceted analyses in the dashboards; these analyses generate knowledge that supports strategic and operational decisions; the decisions lead to the optimization of the course offer and management processes; the optimized offer produces better results in terms of effectiveness (greater employability and adequacy of skills), efficiency (better use of resources) and relevance (response to changes in the industrial market); and these results, in turn, generate new data that feeds back into the cycle, promoting constant improvement.

The consistent application of this data-intensive ADD approach can be seen in the results obtained by the institution in surveys carried out on an ongoing basis. An example is the result of the Professional Assessment Performance Indicator – IDAP (overall average in each test and the distribution of students by levels of the performance scale), which in 2024 reached the systemic result of 7.8, the highest result since the beginning of the Programme in 2021. It is also worth noting that in a survey[3] carried out by SENAI in 2024, 85.6 percent of former students of technical courses are employed within a year of completing the course and 90.5 percent of companies prefer to hire professionals trained by SENAI. These figures demonstrate the consolidation and strengthening of SENAI's quality in the Brazilian Vocational and Higher Education scenario.

The use of ADD gives the institution the agility it needs to respond effectively to disruptive demands, ensures dynamic alignment with the constantly evolving needs of the national industry, promotes the optimal use of resources and demonstrates an active commitment to promoting equity and social inclusion. In doing so, SENAI positions itself not merely as a training provider, but as a strategic national asset, fundamental to shaping the future of the Brazilian workforce and industry in a world undergoing accelerated transformation.

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Maw Maw Tun and Cherry Tin

Leveraging Data Analytics and Reporting for Evidence-Based TVET Policy in Myanmar

The development of effective Technical and Vocational Education and Training (TVET) policies in Myanmar increasingly relies on data-driven decision-making. By leveraging data analytics and reporting, policymakers can design evidence-based strategies that address workforce demands, strengthen curriculum development, and enhance training programme effectiveness. This study examines the role of data analytics and reporting in shaping TVET policies under the Department of Technical and Vocational Education and Training, primarily through a secondary analysis of research, reviews, and reports. It evaluates the current state of data utilization, explores successful case studies that have informed policy decisions – particularly in training needs assessment, curriculum development, and programme evaluation. Furthermore, it identifies key challenges in leveraging data analytics for TVET policy in Myanmar and provide recommendations to strengthen data-driven decision-making and enhance policy effectiveness in Myanmar.

1 Introduction

Technical and Vocational Education and Training (TVET) plays a crucial role in equipping learners with the skills needed for employment, decent work and entrepreneurship while supporting inclusive and sustainable economic growth (UNESCO-UNEVOC 2025).[1] In Myanmar, the development of effective TVET policies increasingly depends on robust data analytics and reporting to ensure that decisions are informed by accurate, timely, and relevant data. This paper aims to explore the role of data analytics and reporting in TVET policy development in Myanmar.

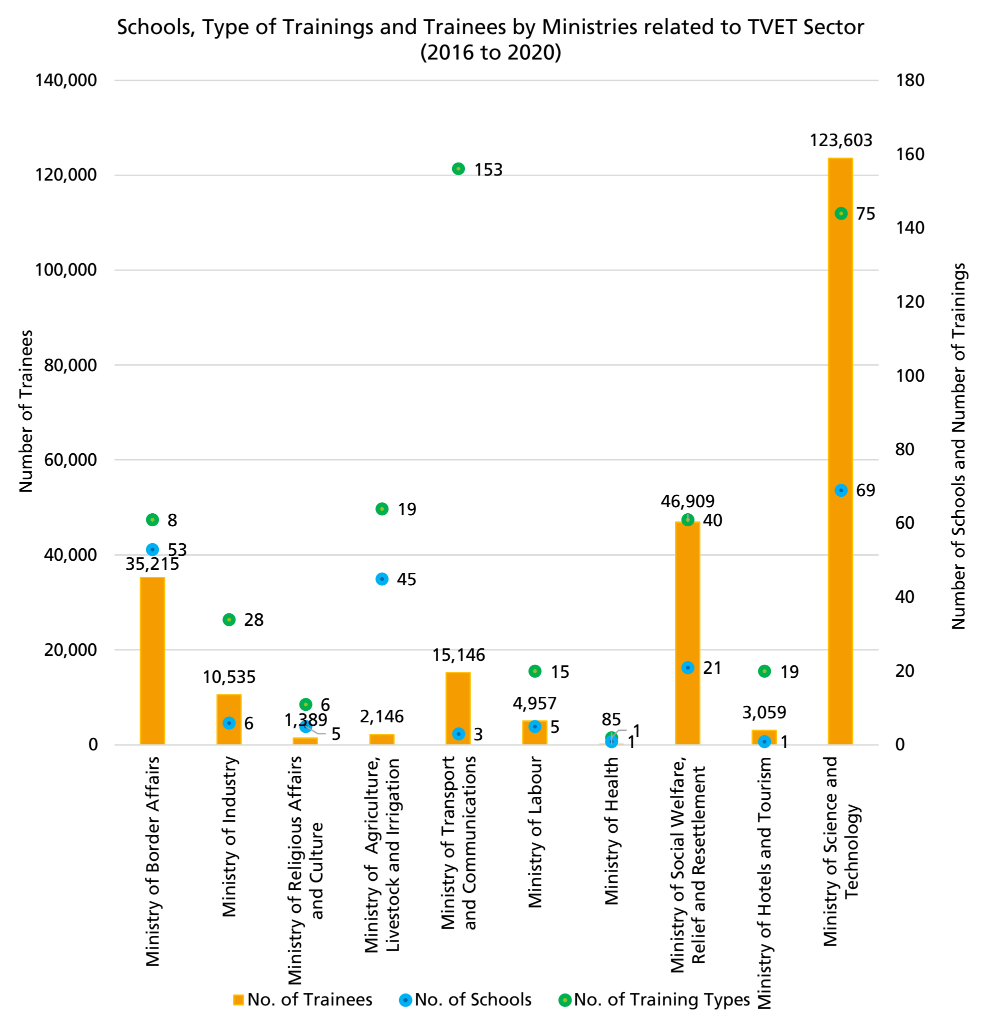
1.1 Overview of the TVET System in Myanmar

TVET provision in Myanmar is undertaken by various ministries and private sector. The TVET sector is comprised of 10 TVET ministries, which are Ministry of Border Affairs, Ministry of Industry, Ministry of Religious Affairs and Culture, Ministry of Agriculture, Livestock and Irrigation, Ministry of Transport and Communications, Ministry of Labour, Ministry of Health, Ministry of Social Welfare, Relief and Resettlement, Ministry of Hotels and Tourism and Ministry of Science and Technology. The Ministry of Science and Technology serves as the focal TVET ministry, responsible for harmonizing and coordinating efforts among multiple line ministries and entities that offer TVET programs in Myanmar. It provides a diverse range of formal educational programs, including Bachelor of Technology degrees, diploma

1 The authors used ChatGPT (GPT-4o, 10.03.2025) for grammar checking and language clarity.

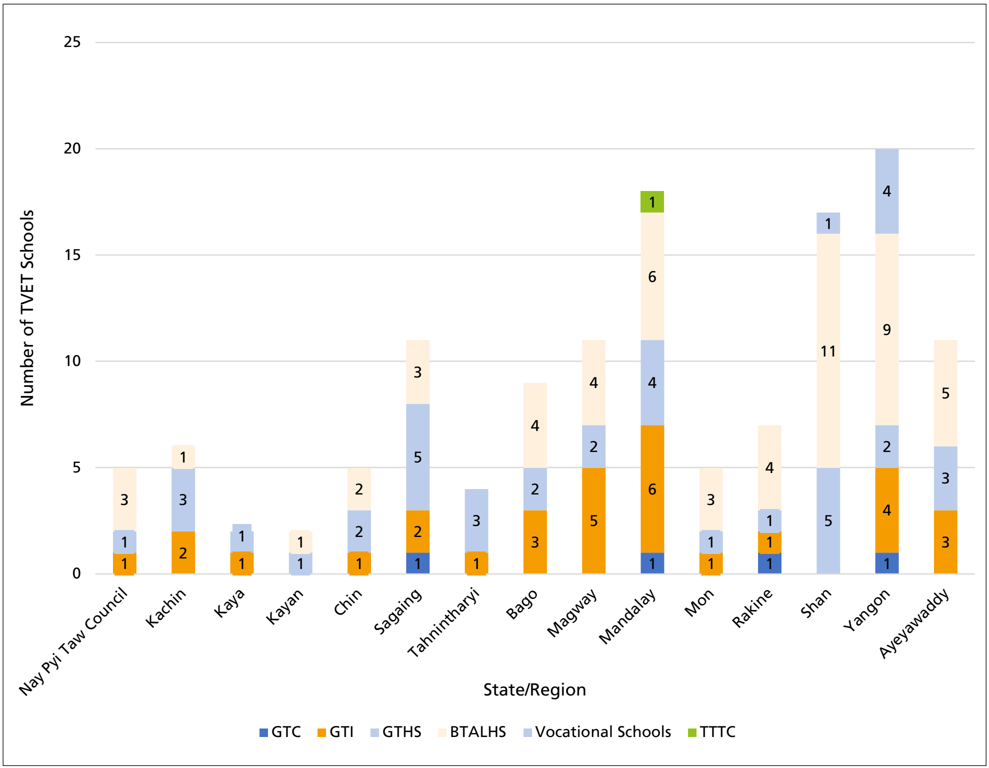
programs, and certificate programs. Additionally, it offers non-formal short courses. Other ministries also provide TVET programs, primarily consisting of short non-formal courses. The schools, type of trainings and trainees by ministries related to TVET sector during 2016–2020 are shown in Figure 1. The Department of Technical and Vocational Education and Training (DTVET) under the Ministry of Science and Technology opened 73 courses, including regular programs and non-formal courses in 69 TVET schools by 2020. As of June, 2024, the ministry has expanded to 133 TVET schools across the regions and states of the country as shown in Figure 2.

Figure 1: Ministries Related to TVET Sector (Regular/Short Term)



Source: Data extracted from Thu 2024

Figure 2: TVET Schools under DTVET by June 2024



Source: DTVET 2024

Note: GTC-Government Technical College (4Nos); GTI- Government Technical Institute (31 Nos); GTHS-Government Technical High School (36 Nos); BTALHS-Basic Technical, Agriculture, Livestock High School (56 Nos); Vocational Schools (VS) (5Nos); TTTC- TVET Teachers Training College (1 Nos)

1.2 Role of Data Analytics and Reporting in TVET in Myanmar

In Myanmar, the role of data analytics and reporting in Technical and Vocational Education and Training (TVET) has become increasingly critical in the context of digital transformation, Artificial Intelligence (AI), and the Fourth Industrial Revolution (IR 4.0). By leveraging advanced data analysis tools and aligning with global trends, TVET institutions can better understand labour market demands, improve curriculum relevance and quality, track graduate outcomes and boost innovation (Tun/Juchelkova 2020; UNESCO 2019). Real-time data reporting supports evidence-based policy-making, enhances resource allocation, and enables the continuous monitoring and evaluation of TVET programs. As Myanmar embraces digital technologies, data-driven decision-making is essential for fostering a more inclusive, adaptive, and future-ready TVET system.

1.3 Problem Statement

Data Analysis and reporting is an emerging trend in TVET of Myanmar. However, most TVET ministries still lacks the data management systems, standardized data collection methods, curriculum review, tracer studies, employer satisfaction and programme effectiveness, etc. (MOST 2022; Tun/Juchelkova 2020; UNESCO 2019). With modern technology advancements, data analysis for evidence-based policy becomes crucial to meet all the stakeholders' needs.

1.4 Aim of the Research and Research Questions

This study aims to examine the role of data analytics and reporting in shaping evidence-based TVET policies and offer recommendations for improving the system. To achieve the aim, the research will address the following three research questions?

(i) How is data analytics currently utilized in the development and evaluation of TVET policies in Myanmar?

(ii) What are the key challenges in leveraging data analytics and reporting for evidence-based decision-making in TVET policy?

(iii) What are recommendations for enhancing the use of data analytics in shaping effective TVET policies in Myanmar?

2 Methodology

2.1 Methodological Approach

Through secondary data analysis sourced from TVET research, reviews, and reports in Myanmar, this study evaluates the current state of data analytics and reporting, identifies key challenges, and examines successful case studies that have contributed to evidence-based policy decisions – particularly in labour market analysis, training needs assessment, TVET curriculum development, and the evaluation of training programme effectiveness. Furthermore, it identifies key challenges in leveraging data analytics for TVET policy in Myanmar and provides recommendations to strengthen data-driven decision-making and enhance policy effectiveness in Myanmar.

2.2 Scope and Limitations

DTVET is a focal TVET department under MOST, where most TVET institutes are offering a variety of TVET programs. Since the ministries related to TVET are fragmented, the study focused on the data analytics and reporting in TVET, conducted by DTVET. Therefore, the majority of the TVET data in this research are collated from DTVET.

As the research limitations, some of the recent data about TVET cannot be accessible due to limited public access to those data in Myanmar since there has been only the initial stage of data analytics and reporting in TVET.

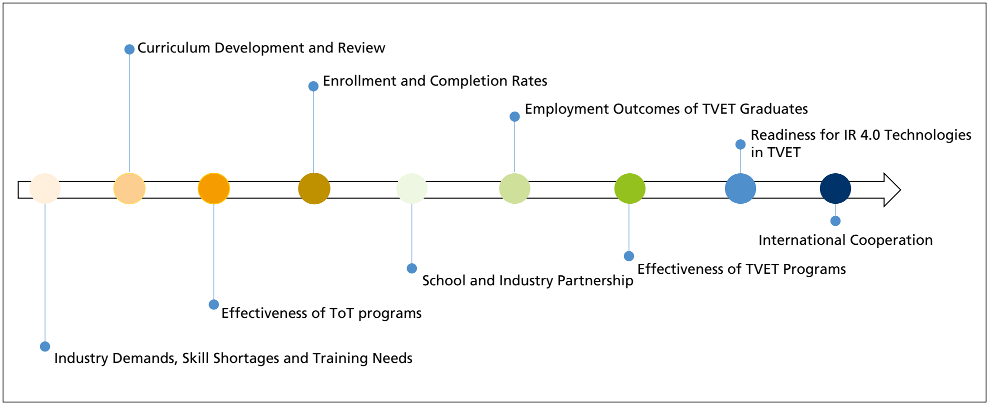
3 Findings and Discussion

3.1 Establishment of Research Section for Data Analysis

In Myanmar, TVET serves as a foundation for workforce development and economic progress for promoting socio-economic development of the country. Therefore, TVET policies are crucial for promoting the TVET sector, enhancing human resource capabilities and increasing economic development. Data-driven decision-making ensures that TVET policies address labour market demands, skills gaps, curriculum development, and employment trends effectively. With the recommended highlights of a previous review on the National Education Strategic Plan (NESP) (2016–2021), the DTVET established a research section at its Headquarters in June 2023 to promote TVET research and development across the country. Since then, the research section has embarked on collecting, analyzing, and utilizing data related to curriculum review, teacher trainings, short-courses, training needs analysis, labour market demands, etc. to inform policy decisions in TVET.

In Myanmar, evidence-based policymaking relies on comprehensive data collection, analysis, and reporting mechanisms. Data analytics and reporting in TVET provide insights into the development processes for fulfilling the industrial needs, developing the curriculum, training of trainers, analyzing the enrollment and completion rates, promoting school-industry partnership, evaluating the employment outcomes of TVET graduates and ensuring the effectiveness of the programs and readiness for IR 4.0 technologies in TVET and enhancing international cooperation (Figure 3).

Figure 3: Role of research section for data analytics and reporting in TVET

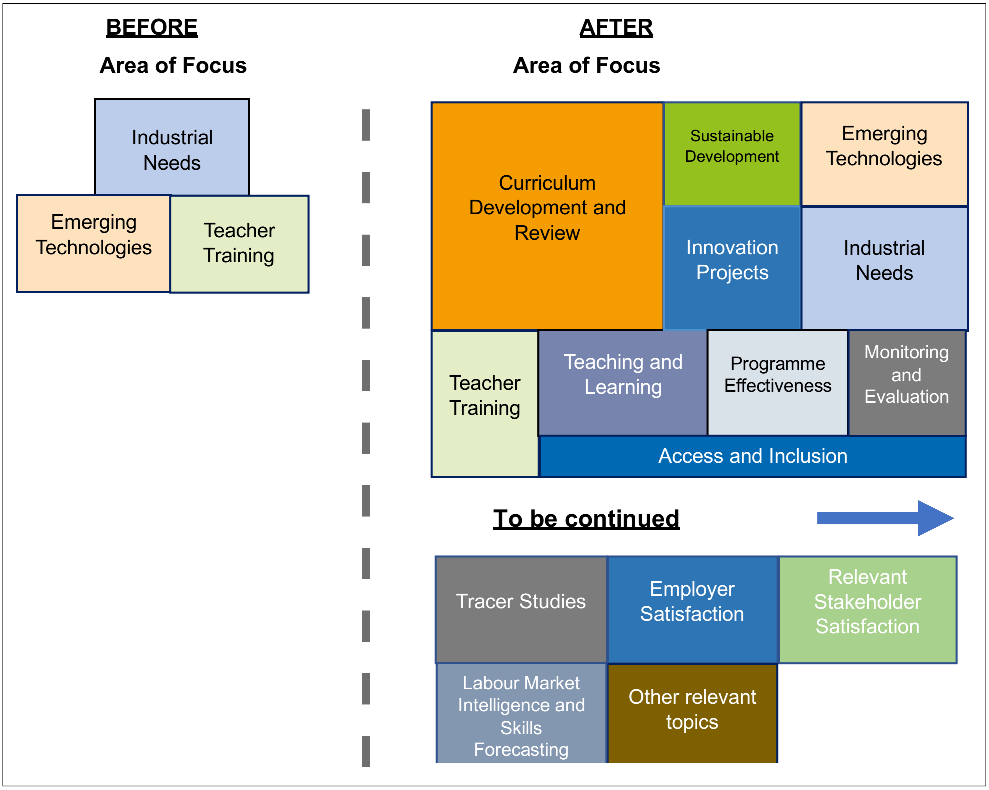


Source: Authors' own work

3.2 Current State of TVET Data Analytics and Reporting in Myanmar

Myanmar has taken steps to enhance TVET data analytics and reporting through initiatives led by DTVET. Figure 4 shows a comparison of data collection and analysis in TVET between before and after the promotion of the role of data in the DTVET, regarding the area of focus. Previously, data collection was primarily limited to industrial needs, emerging technologies, and teacher training, with minimal stakeholder involvement and little influence on policy. In contrast, after the promotion of the role of data, the focus expanded to include curriculum development, teaching and learning, and advanced technologies such as AI. Data is now used to support evidence-based decision-making, strategic planning, and continuous improvement. Stakeholder engagement has increased, and systematic plans for future data collection through surveys, focus groups and interviews – such as tracer studies and labour market forecasting – are in place. As a result, data now plays a central role in shaping proactive, responsive, and high-quality TVET policies and practices.

Figure 4: A comparison of data collection and analysis in TVET between before and after the promotion of the role of data in the DTVET, regarding the area of focus



Source: Authors' own work

3.3 Successful Case Studies for Informed TVET Policy Decisions

Several case studies highlight how data analytics have shaped effective TVET policies in Myanmar. One case study illustrates the use of real-time big data analytics and artificial intelligence (AI) to support skills development by identifying high-demand skills and job titles across industries, as well as the requirements for job applications. The results provide evidence-based insights that support not only educational planning by policymakers and partner agencies but also enable job seekers and households to make informed, data-driven decisions regarding careers and personal development (UNESCO 2019).

The second case study demonstrates the transition from the National Education Strategic Plan (NESP) 2016–2021 to the Science, Technology and Innovation Strategic Plan (STISP) 2022–2027, reflecting data-informed policy shifts within the TVET sector (NESP, STISP) (MOE 2018; MOST 2022). As a result, significant reforms have been implemented in the TVET system, including curriculum revision, teacher training, infrastructure development, the integration of emerging technologies, entrepreneurship education, school-industry partnerships, and research and development. Key areas of impact include enhanced quality assurance, improved programme effectiveness, and the development of industry-responsive skilled labour.

The third case study illustrates the data collection and data-based policymaking for the development of the TVET sector in Myanmar (Table 1).

Table 1: Data collection and data-based policymaking for the development of the TVET sector in Myanmar

School	Programs/ Description	Data to be collected for	Type of Data	Frequency	Types of Respondents	Number of Respondents	Data Collection Methods	Data Analytics (Excel, etc.)	Data Reporting to the Department	Policy Recom-menda-tions	Guidelines to actions for improvement in TVET system
GTHS	Regular Certificate Programme	Training Needs, Curriculum Review, Teaching and Learning, Emerging Technologies	Quantita-tive and Qualitative	Once per semester	Principal, Teachers, Students	>1000	Survey	√	√	√	√
BTALHS			Quantita-tive and Qualitative	Once per semester	Principal, Teachers, Students	>200	Survey	√	√	√	√
GTI	Diploma Programme		Quantita-tive and Qualitative	Once per semester	Principal, Teachers, Students	>1500	Survey	√	√	√	√
GTC	Bachelor of Technology		Quantita-tive and Qualitative	Once per semester	Principal, Teachers, Students	>200	Survey	√	√	√	√
VS	Certificate Programme	Emerging Technologies, Training Needs	Quantita-tive and Qualitative	Varies	Principal, Teachers, Students	>200	Survey	√	√		
TTTC	Preservice and In-ser-vice Teachers Training	Teaching Methods, Curriculum, Programme effectiveness	Quantita-tive and Qualitative	Once per post-training	Trainees, Trainers	>500	Survey	√	√	√	√

School	Programs/ Description	Data to be collected for	Type of Data	Frequency	Types of Respondents	Number of Respondents	Data Collection Methods	Data Analytics (Excel, etc.)	Data Reporting to the Department	Policy Recom-menda-tions	Guidelines to actions for improvement in TVET system
All TVET Schools	Access and Inclusion	Reasons from drop-outs, In-clusive access to programs	Quantita-tive and Qualitative	Varies	Principal, Administra-tors, Teachers, Students	>500	Survey	√	√	√	√
	Skills Com-petition and Innovation Project Com	Effectiveness of the compe-titions	Quantita-tive and Qualitative	Once a year	Teachers, Students, Assessors	>300	Survey	√	√	√	√
	Monitoring and Evalu-ation	Implemen-tation of TVET Strategies and Activities	Quantita-tive and Qualitative	Once a year	Principal, Administra-tors, Teachers, Students	>3000	Survey	√	√	√	√
	Emerging Technologies	Awareness and Applica-tion of Green Skills, Industry 4.0 technol-ogies includ-ing AI	Quantita-tive and Qualitative	Varies	Principal, Teachers, Students	>3000	Survey	√	√	√	√

Source: Research Section 2025

3.4 Key Challenges in Leveraging Data Analytics for TVET Policy in Myanmar

Key challenges include:

(i) Most TVET-relevant ministries have fragmented and non-standardized data collection, leading to limited data accessibility and data reliability.

(ii) Inadequate infrastructure, limited technical expertise, and low analytical capacity within TVET institutions also hinder progress in data analysis and reporting.

(iii) Insufficient human and financial resources, weak coordination among stakeholders and policy implementation gaps further restrict effective data-driven decision-making.

3.5 Recommendations for Strengthening TVET Data Analytics and Reporting

To enhance the use of data analytics in shaping effective TVET policies in Myanmar, the following recommendations are provided:

(i) It is essential to strengthen data governance frameworks, develop a centralized TVET data management system integrating data across institutions, and standardize data collection practices for consistency and accuracy.

(ii) Leveraging digital tools, AI, and big data analytics can significantly improve data processing and visualization.

(iii) Strong collaboration among government agencies, the private sector, and international partners can foster richer data ecosystems and improve data utilization.

(iv) Investing in capacity building and data literacy for policymakers, educators, and administrators is crucial to ensure evidence-based decision-making.

(v) Adopting international best practices will support the modernization of data-driven TVET systems.

4 Conclusion

In Myanmar, the development of effective TVET policies increasingly depends on robust data analytics and reporting to ensure that decisions are informed by accurate, timely, and relevant data. By leveraging data analytics and reporting, addressing existing challenges and adopting strategic improvements, Myanmar can strengthen its TVET system to better align with labour market needs and support national development goals. With the advancement of technologies, DTVET plans to promote the role of data analytics and reporting for Myanmar TVET sector development. Implementing evidence-based policy advice through enhanced data analytics and reporting will lead to improved workforce outcomes, economic growth, and social progress in the years to come.

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Zakaria Sulemana and Samuel Thompson

Evidence-Based TVET Policy Through Data Reporting and Data Science in Ghana

Ghana's Technical and Vocational Education and Training (TVET) sector is increasingly adopting data-driven approaches to inform policy and reform. Spearheaded by the Commission for TVET (CTVET), structured data collection and analysis underpin the monitoring of core indicators such as TVET governance, enrolment trends, access and inclusion, quality of TVET, environmental sustainability, international cooperation and TVET financing mechanisms. This paper explores Ghana's evolving TVET reporting system, its methodology, progress, and key challenges in implementing evidence-based governance. Drawing on the Ghana TVET Reports (Commission for TVET 2021; 2023), the paper offers an insight into key findings of the reports, recommendations for strengthening TVET data systems and policy responsiveness.

1 Introduction

Technical and Vocational Education and Training (TVET) plays a pivotal role in Ghana's socio-economic development, serving as a catalyst for skills development, employment, and industrialization. In alignment with the Education Regulatory Bodies Act (Act 1023) (Republic of Ghana 2020), the Commission for TVET (CTVET) has institutionalized data-driven policy mechanisms through periodic TVET data reporting. The Ghana TVET Report produced with technical support from the Federal Institute for Vocational Education and Training (BIBB) and the Central Office for International Cooperation in VET (GOVET) provides evidence-based insights to guide TVET reforms, investment, and planning (Commission for TVET 2021).

2 Background and Context

The TVET reporting system in Ghana reflects a broader effort to integrate monitoring and evaluation into policy design and implementation. Data reporting plays a crucial role in identifying skills gaps and aligning curricula with labour market demands. One of Ghana's most significant data-driven initiatives is the Ghana TVET Report, developed by CTVET since 2021. The Ghana TVET Report consolidates data from public and private providers, presenting metrics on enrolment trends, access, gender inclusion, financing, quality assurance, and industry engagement (Commission for TVET 2023). Complemented by national initiatives such as the Education Management Information System (EMIS), CTVET's bespoke monitoring platform evaluates governance structures, compliance, infrastructure, and institutional performance through self-assessments and independent verification processes.

3 Methodology

Ghana has demonstrated a strong commitment to evidence-based TVET policymaking through CTVET's ongoing efforts to establish a centralized national database for monitoring learner trajectories and institutional performance. The Ghana TVET Report is developed by an in-house team often referred to as "Author Teams" from various departments across the organization. The process follows a multi-stage process, which ensures that objectives and thematic areas are aligned with the national Education Strategic Plan (ESP) (Ministry of Education 2018) and national TVET policy goals (ibid.). Stakeholders including TVET providers, regulatory bodies, and industry partners are consulted in the design of standardized data collection instruments. The number of respondents (training providers) has increased from the 85 in 2021 to 231 in 2023 due to strong stakeholder engagements. The data, collected digitally after respondent training, is cleaned, analyzed, and validated through stakeholder workshops. The draft report undergoes review and is finalized for publication and official launch, ensuring policy relevance and broad dissemination (Commission for TVET 2021).

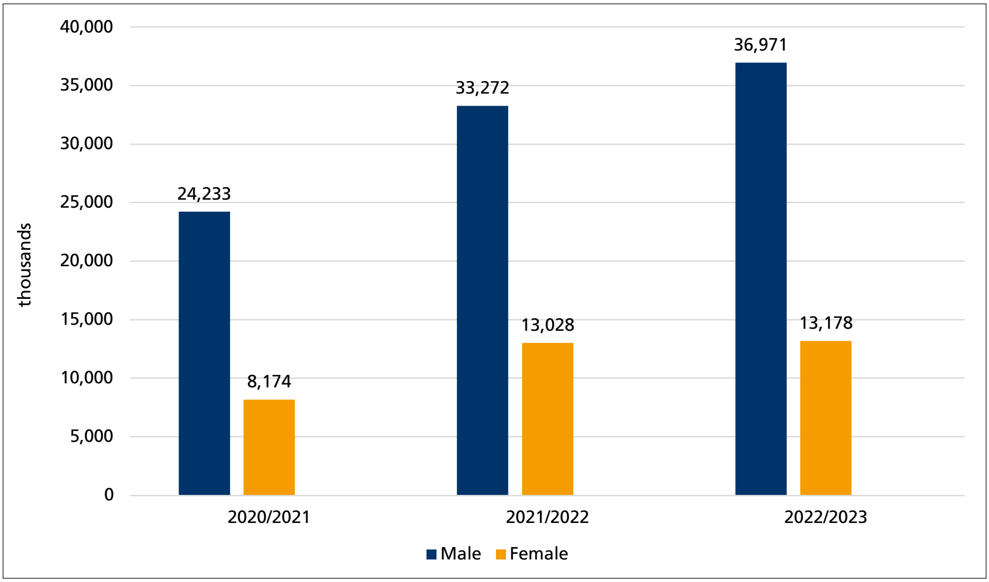
4 Key Findings

The Ghana TVET Report highlights major progress, ongoing challenges, and strategic reforms in the TVET sector.

4.1 Enrolment trend

Between 2020/2021 and 2022/2023, pre-tertiary TVET enrolment increased by 54 percent, reaching over 50,000 students. Female enrolment rose from 25.2 percent to 26.3 percent, with tertiary female enrolment growing by 90 percent between 2016 and 2022 (Commission for TVET 2023).

Figure 1: Pre-tertiary enrolment per gender (in thousands)



Source: Commission for TVET 2023

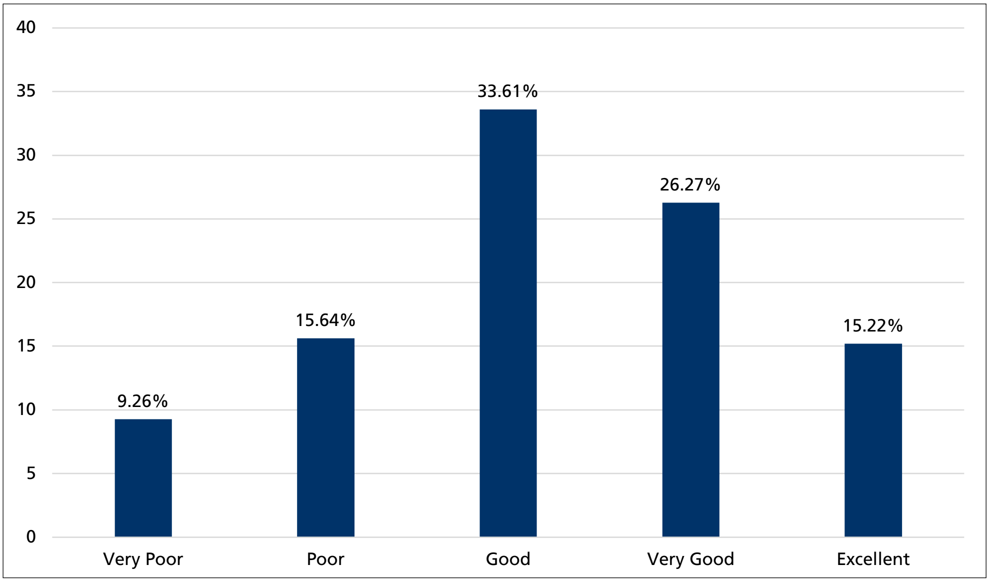
4.2 Access and Government Interventions

Significant government interventions helping to increase economic access to TVET include, Free TVET Policy which is accessible to all public TVET Institutions. Under the Ghana TVET Voucher Project (GTVP), over 19,000 Master Craftsperson's and apprentices were trained and certified in various trade areas. Again, the Ghana Education Outcomes Project (GEOP) and Jobs and Skills Projects, targeted efforts to integrate out-of-school youth and enhance workplace-based learning. Withing the period, the government has constructed 4 TVET Centres of Excellence with state of the art workshops and equipment, rehabilitated 34 TVET Institutions (formerly under NVTI) and upgraded and retooled 23 TVET Institutions with modern tools and equipment.

4.3 Quality of Infrastructure and Training Facilities

A survey of 231 institutions showed that nearly all have access to workshops or laboratories, though only 33.6 percent of classrooms are in good condition. Computer labs, libraries, and guidance services remain inadequate in some regions (Commission for TVET 2023).

Figure 2: Condition of Classroom/Facilitation Room (in %)



Source: Commission for TVET 2023

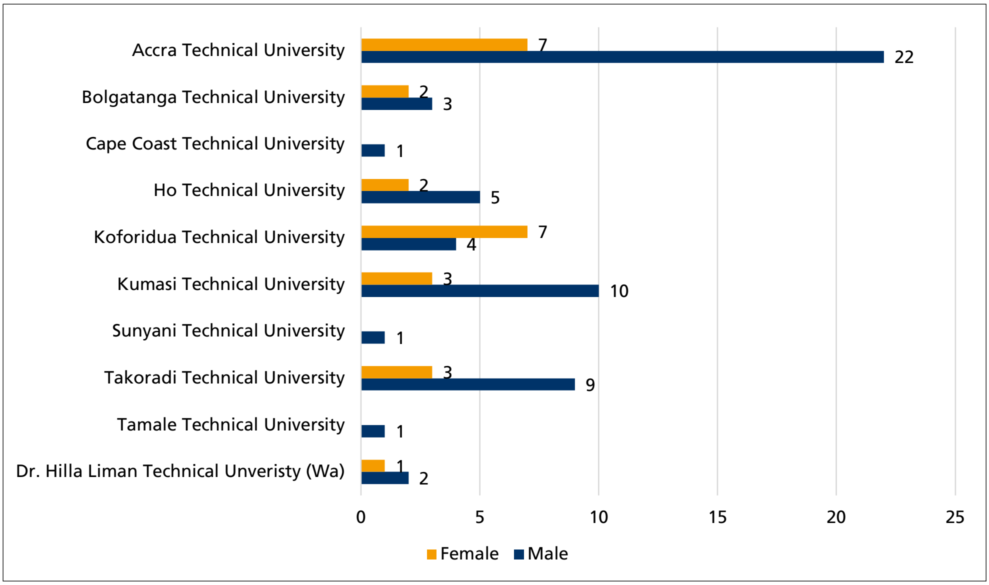
4.4 Gender and Inclusion

Of the 231 TVET institutions that participated in a survey for the second TVET report, a total of 357 Learners with Special Needs (LWSNs) were enrolled across 77 Institutions. Majority of the LWSNs are males (57.4%) and females (42.6%). However, the lack of assistive devices and support mechanisms remains a barrier to inclusive education (Commission for TVET 2023).

4.5 Financing and Scholarships

TVET financing combines government subventions, donor support, and internal revenue. Figure 3 shows government scholarships in ten Technical Universities, the data revealed a gender gap in scholarship distribution: 69 percent of beneficiaries are male.

Figure 3: GETFund Scholarship Distribution Technical Universities (2021–July 2023) (in %)

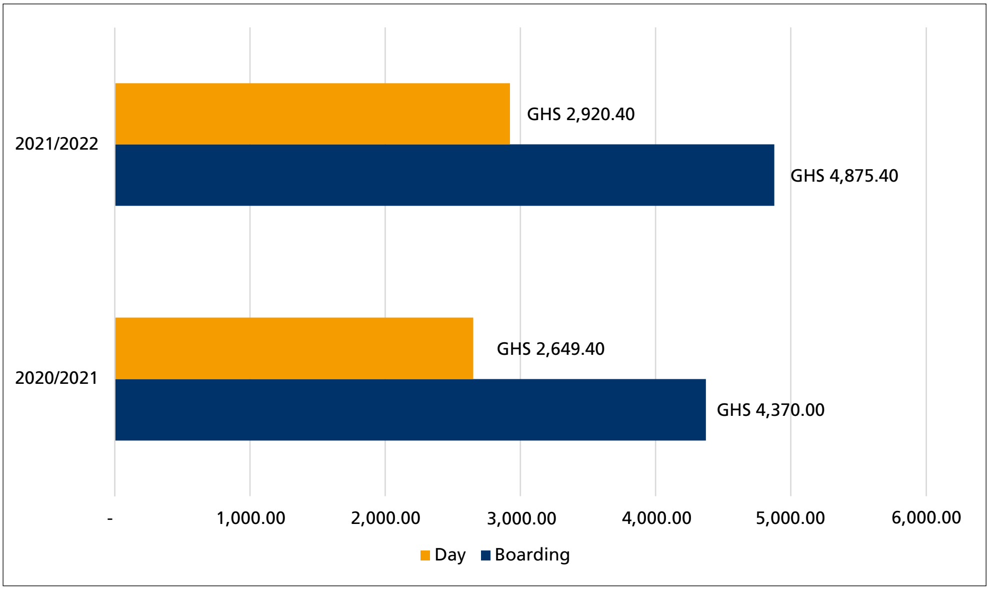


Source: *Commission for TVET 2023*

The cost per learner under the free TVET policy rose by over 10 percent between the academic years 2020/2021 and 2021/2022 (Commission for TVET 2023).

The cost per learner under the free TVET policy saw an increase of 10.23 percent in the 2021/2022 academic year, reaching GHS 2,920.4 for non-residential learners (meaning learners that do not benefit from boarding at the TVET institutions) and GHS 4,875.4 in the 2021/2022 academic year, reflecting an almost 11.57 percent increase. This provides insights into the financial dynamics of the free TVET policy and the associated costs per learner.

Figure 4: Cost of Free TVET Per Learner (2020/2021 and 2021/2022) (in GHS)



Source: Commission for TVET 2023

4.6 Industry Engagement and Curriculum Reform

In response to labour market demands, twelve Sector Skills Bodies (SSBs) have been inaugurated to strengthen industry-led curriculum design and skills alignment (Commission for TVET 2023). Again, more than 70 companies have expressed interest in supporting the implementation of Dual TVET. The report included an overview of training curricula developed and under development.

Table 1: Contribution of SSBs towards Skills Development

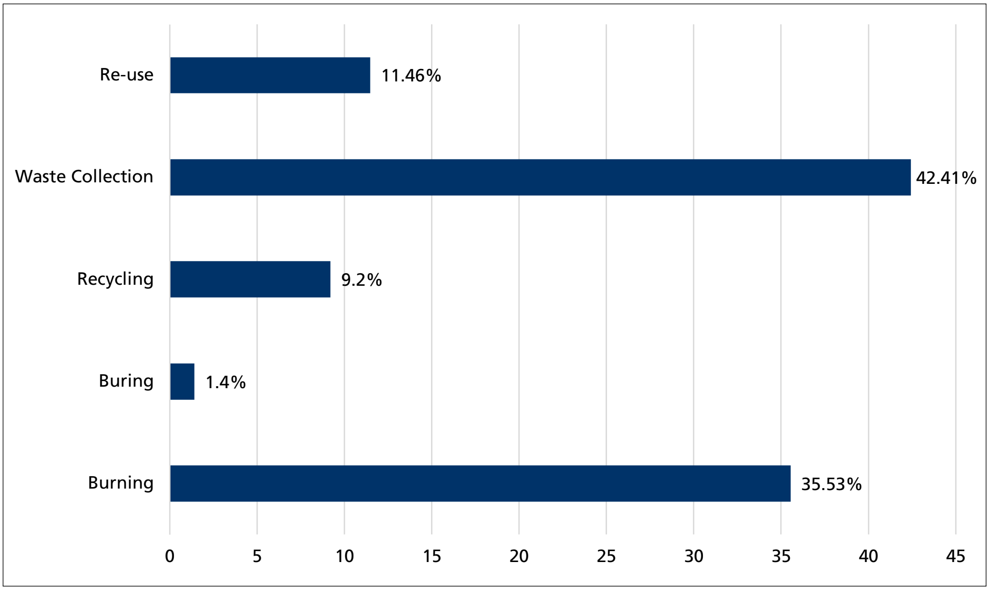
No.	Sector Skills Bodies (SSBs)	Number of Competency-based-training Curriculum developed	Number of Competency-based-training Curriculum under development
1	Construction SSB	19	16
2	Agricultural SSB	17	3
3	ICT SSB	16	9
4	Hospitality and Tourism SSB	5	9
5	Renewable Energy SSB	2	1
6	Healthcare SSB	0	0
7	Pharmaceutical SSB	0	4
8	Automotive SSB	5	5
9	Oil and Gas	2	0
10	Logistics and Transport SSB	0	0
11	Textiles, Apparel and Garment	10	6
12	Beauty and Wellness SSB	4	6
13	Other Training packages	28	56
	Total	**108**	**115**

Source: Commission for TVET 2023

4.7 Environmental Sustainability

Greening TVET initiatives promote recycling and renewable energy use. However, infrastructure limitations constrain implementation, especially in rural areas. Waste management has been a major challenge to many TVET institutions (Commission for TVET 2023).

Figure 5: How institutions dispose of their solid waste (in %)



Source: Commission for TVET 2023

5 Challenges

The report identifies several challenges in data reporting, including limited access to labour market information data, financial support for data harmonization and weak internet infrastructure for digital data capture, and lack of disaggregated data by gender and vulnerability status. Coordination among private providers also remains limited, affecting data harmonization (Commission for TVET 2021; 2023).

5.1 Addressing Challenges in Data Reporting and Monitoring

The Commission has initiated standard data collection frameworks and adopted digital tools to improve data management and analysis. Strategic collaborations with industry stakeholders, the Ministry of Labour, Jobs and Employment, and the Ghana Statistical Service, complemented by regular audits, are being pursued to enhance data integrity and ensure alignment with labour market needs.

6 Policy Initiatives and Interventions facilitated by TVET Reports

The Ghana TVET Reports have facilitated implementation of several key policy initiatives and interventions aimed at improving the TVET sector. These include the establishment of twelve Sector Skills Bodies (SSBs) to enhance industry-led curriculum development, expansion of the Free TVET Policy to increase access, and major infrastructure investments such as the construction of Centres of Excellence and retooling of institutions. The reports also prompted inclusive education measures for learners with special needs, the adoption of a Greening TVET Strategy to promote environmental sustainability, and the development of a centralized TVET Management Information System (TVETMIS) to improve real-time data monitoring and policy responsiveness. These interventions demonstrate a strong shift toward evidence-based planning and sector reform. The Commission has put in a lot effort to further strengthen the team's capacities in data analysis, among others through data analysis and data management trainings financed by the BMBF.

7 Recommendations and Conclusion

7.1 Policy Recommendations

To enhance data-based governance, the development of a centralized TVET Management Information System (TVETMIS) is essential. Investments should prioritize digital infrastructure, capacity building in data science, and the institutionalization of data quality protocols. Strengthened partnerships with industry and national statistical agencies are critical for real-time labour market intelligence (Ministry of Education 2018; Commission for TVET 2023).

7.2 Conclusion

Ghana's data-driven approach to TVET policy offers valuable lessons for evidence-based governance in education. While progress has been made in enrolment, access, and system reform, challenges remain in financing, gender parity, and infrastructure. Sustained investments in data systems and stakeholder collaboration are key to deepening reforms and preparing a skilled workforce aligned with national development goals.

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Hubert Ertl, David Polk, and Ellie Hartman[1]

Comparative Analysis Report: Data-Based Labor and Apprenticeship Policies in Germany and Wisconsin (USA)

This contribution presents a comparative analysis of data-based labor and apprenticeship policies in Germany and the U.S. state of Wisconsin. It examines systemic frameworks, data infrastructures, participation trends, and labor market analytics. Germany's structured dual system and long-term training provision contrast with Wisconsin's decentralized but data-rich approach. Both cases highlight the importance of responsive, evidence-driven strategies to address skilled labor shortages. The contribution emphasises the value of cross-national learning and robust data use in shaping effective vocational education and training (VET) policy.

1 Systemic and Legal Framework

Germany operates a nationally standardized dual vocational education and training (VET) system, regulated by the Vocational Training Act, enshrined in law since 1969. It combines practical training in companies with theoretical instruction in vocational schools, spanning 2 to 3.5 years. Each year, about 50 percent of German school-leavers enter dual training programs, with over 1.2 million trainees in 2023.

Wisconsin has been a pioneer in U.S. apprenticeship since 1911 for registered apprenticeship, and since 1991 for youth apprenticeship. Both programs are overseen by the Department of Workforce Development (DWD). Wisconsin registered apprenticeships span 1 to 5 years and include on-the-job training under supervision of skilled workers and related classroom training. Wisconsin youth apprentices are juniors and seniors in high school, and also earn while they learn, similar to registered apprentices.

The sponsor of registered apprentices (often an employer) pays for both hours worked, and hours related to instruction. The apprentice works at a reduced wage while learning the trade, and wages increase as the apprentice attains more skill. Wisconsin's Bureau of Apprenticeship Standards (BAS) registers sponsors of apprenticeships that meet current industry standards. Once approved, the sponsor and the apprentice enter into a written

1 The Wisconsin team would like to acknowledge the data analyses and written contributions provided by Alex Verink and Jaspreet Kaur, as well as the ongoing information and support regarding the Wisconsin apprenticeship programs provided by Andrew Kasper, Dominic Robinson, and Craig Henrickson. The descriptions of the figures for the accessible version of this article were created with the help of ChatGPT 4.0, 08.09.2025.

agreement that specifies the length of training, related school requirements, skills to be learned, and wages the apprentice will earn. In 2024, there were 17,452 registered apprenticeships, with 4,318 new contracts, and 504 (or 11.7%) of these new registered apprenticeships contracts included individuals who had a youth apprenticeship in last 3 years.

Youth apprentices receive training on-the-job where the employer teaches skills of the occupation, and in the classroom in courses related to the occupation. The employer, youth apprentice, parent/guardian, school representative, and youth apprenticeship coordinator sign an Education and Training Agreement where the employer agrees to provide at least 450 hours of work per year under the supervision of a workplace mentor and to train the apprentices in competencies and skills that are pre-determined by industry leaders. There were 9,929 youth apprenticeships in the 2023 to 2024. Both programs offer structured, paid work experience and classroom instruction tailored to labor market needs across sectors, including long-standing registered apprenticeships in construction, manufacturing, and service industries, as well as recent apprenticeships in healthcare and education. About 0.5 percent of Wisconsin's population of 5.961 million, or more than 27,000 Wisconsin residents, had an apprenticeship in 2024, consistent with the prevalence of apprenticeship rates across the United States.

2 Data Systems and Infrastructure

In order to monitor and evaluate the training and labor market Germany uses data on training and employment contracts and conducts research-based data surveys; Wisconsin analyzes apprenticeship and unemployment insurance administrative data, as well as local, state, and national labor market information.

Germany's Federal Institute for Vocational Education and Training (BIBB) conducts annual surveys on new training contracts, supplemented by labor market data from the Federal Employment Agency (BA). These datasets track a variety of trends, including supply/demand dynamics, demographics, premature contract dissolutions, and regional mismatches.

In order to generate market data, the BIBB combines its own survey data with data originating from labour statistics produced by the BA. They include the companies and applicants registered with the advisory and placement services of the BA. These services aim to provide support for (potential) applicants as well as prospective training companies. Young people are only registered as applicants if individual suitability for the training occupations they wish to enter has been clarified. Similarly, companies need to fulfill eligibility criteria before they can offer dual system training. Most importantly, there must be a qualified in-company trainer who can conduct training. These criteria are specified in the Vocational Training Act and are supervised by the relevant Chambers.

The figures for the supply of training places include the number of newly-concluded training contracts generated by the BIBB as part of its survey conducted annually as of 30 September (supply of training places filled successfully) and training places registered with the BA and not filled as of 30 September (places not successfully). The figures on

demand also include the number of new training contracts (met demand) and applicants registered with the BA as still looking for training (unmet demand).
Wisconsin collects detailed administrative apprenticeship data, including contract status, demographics, and wages. These data are linked to Unemployment Insurance (UI) wage records, creating a longitudinal database for evaluating program outcomes and labor market impacts. Co-enrollment tracking across workforce programs (e.g., veterans, vocational rehabilitation) enhances analytical depth.

The Wisconsin Bureau of Apprenticeship Services at the Department of Workforce Development (DWD) collects information for each apprenticeship contract between the apprentice and the employer. Data include contract status (applicant, active, completed, canceled, unassigned), contract status date, apprentice demographics, job location, trade, occupation, and end wage rate. Staff use these data to inform local programming and complete federal reporting requirements for the Registered Apprenticeship Partners Information Database System[2] (RAPIDS).

Staff use the information collected on contracts to track overall apprenticeship trends, and trends by trade and occupation, allowing the program to track if current apprenticeship training will help meet the local demand for skilled workers. These data also allow the program to track apprenticeship completion rates. Reported demographic information provides the opportunity to track counts and percentages of apprentices by gender, race, ethnicity, veteran status, and disability. Further, the Wisconsin apprenticeship program conducts an apprenticeship review to track apprentices work experience and related instruction. Apprentices report on their employment status, wages based on compensation specified in the apprentice contract, and satisfaction with both employment and related instruction.

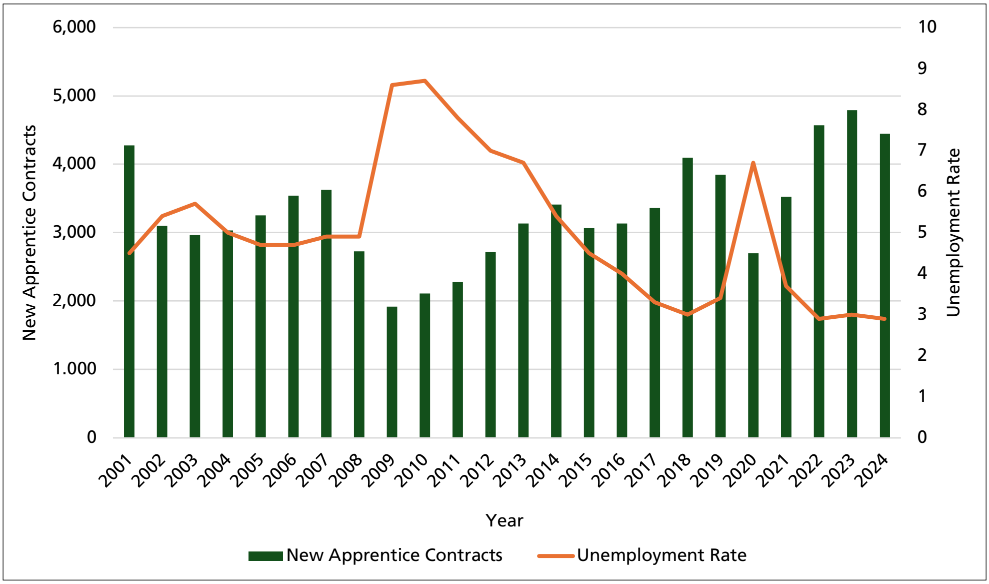
A sample of how the registered apprenticeship program uses data can be found at the apprenticeship resources and data webpage[3]. In one example, the Bureau of Apprenticeship Standards Year in Review[4] includes a graph comparing counts of new apprentice contracts and unemployment rates by year in Wisconsin. This graphic shows that employers are more likely to hire new apprentices in years with lower unemployment rates.

2 See URL: **https://www.apprenticeship.gov/help/what-rapids** (Retrieved on 27.08.2025).

3 See URL: **https://dwd.wisconsin.gov/apprenticeship/facts-data.htm** (Retrieved on 27.08.2025).

4 See URL: **https://dwd.wisconsin.gov/apprenticeship/pdf/BAS-2024YearInReview.pdf** (Retrieved on 27.08.2025).

Figure 1: Wisconsin Apprenticeship Contract Counts versus Unemployment Rates



Source: Replica (with some formatting changes) according to Wisconsin Department of Workforce/ Development Bureau of Apprenticeship Standards 2024

In another example, the Characteristics of Active Apprentice Contracts[5] show that the demographics of apprentices in the state appears to be slowly changing. In 2019, 6 percent of active apprentices were women, compared with 8 percent in 2024. Similarly, the proportion of non-white apprentices grew over the same time-period from 11 percent to 15 percent.

Wisconsin also has a growing youth apprenticeship program that provides opportunities for 16- to 18-year-old high school students to receive on-the-job training and related instruction to start their career pathway within a variety of career clusters. The youth apprenticeship program data provides counts of youth apprentices and employers by school year and career cluster[6]. Additional data are collected on youth apprentices' demographics and high school district. More recently, due to a data infrastructure upgrade, state apprenticeship staff have been able to track the bridge from youth apprenticeships to registered apprenticeships. Co-enrollment reports count the number of youth apprentices who had a subsequent registered apprenticeship in the same years as their youth apprenticeship exit or began a registered apprenticeship one, two, or three years later. The percent of youth apprentices who bridge to registered apprenticeship is increasing overtime, and remains a focus of apprenticeship state staff, as they look to determine how to support this trend to continue.

5 See URL: **https://dwd.wisconsin.gov/apprenticeship/appr_stats/active_appr_characteristics_bytrade.pdf** (Retrieved on 29.08.2025).

6 See **https://dwd.wisconsin.gov/apprenticeship/ya/yoda.htm** (Retrieved on 29.08.2025).

Table 1: Wisconsin Youth to Registered Apprenticeship (RA) Counts

RA Start State Fiscal Year	Total RA Starts	Total RA Starts with YA in Last 3 Years	Percent YA to RA in 3 Years
2018	3,246	81	2.5%
2019	3,578	150	4.2%
2020	2,949	187	6.3%
2021	2,824	243	8.7%
2022	3,569	337	9.4%
2023	4,429	458	10.3%
2024	4,318	504	11.7%

Source: Own Representation based on Wisconsin Department of Workforce/Development Bureau of Apprenticeship Standards 2024

As part of an effort at integrating workforce development data, the Wisconsin Data Integration System (WDIS) team has created the Longitudinal Workforce Database (LWD) which incorporates data on both youth apprentices and registered apprentices along with data from other DWD programs. One particularly important source of linked data is the Wisconsin Unemployment Insurance wage data, which records the quarterly wages for most individuals working in Wisconsin[7]. Using UI wage data, DWD staff have been able to trace employment and wages for individual before, during, and after participation in apprenticeships. In a recent analysis, WDIS staff found that those enrolled in a registered apprenticeship earned over $5,000 per quarter ($20,000 per year) more after their apprenticeship and were 20 percent more likely to be employed relative to those who did not have a registered apprenticeship but had similar demographics, education, and pre-program wages.

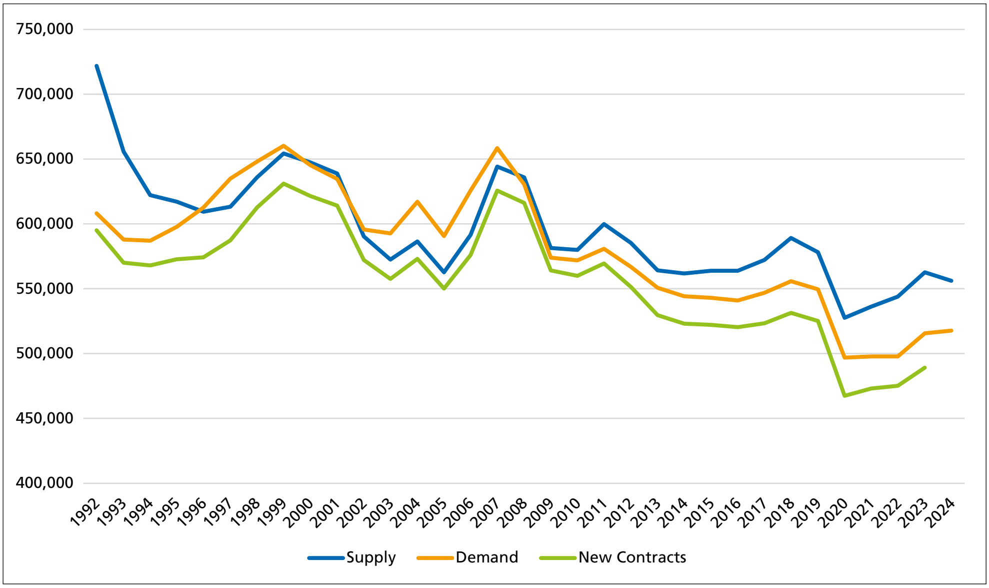
In addition to linking apprenticeship records to wage data, the LWD also enables DWD to analyze patterns of co-enrollment between apprenticeship and other employment and training programs. Co-enrollment reports track both co-enrollment counts overtime, and the influence of co-enrollment on employment outcomes. These reports have consistently found that individuals from other programs like vocational rehabilitation and veterans employment programs who co-enroll in apprenticeships have better employment outcomes than their peers without an apprenticeship experience. For example, apprentices who self-report having a disability who co-enroll in vocational rehabilitation have higher wages, with an increase of more than $700 in quarterly wages for registered apprentices with a self-reported disability and over $1,000 more in quarterly wages for youth apprentices with a self-reported disability. Further, published research has reported that youth with vocational rehabilitation services earned $2,000 more in quarterly earnings when they had a youth apprenticeship (Hartman et al. 2024). Geographic and temporal patterns of co-enrollment are also shared, so staff can use co-enrollment trends to inform policy and practice to better support co-enrollment.

7 See **https://dwd.wisconsin.gov/uiben/wagehome.htm** (Retrieved on 29.08.2025).

3 Participation Trends and Completion Rates

In the longer-term perspective, the participation in the **German** dual system training has decreased. For instance, in 2010, over 1.5 million trainees were part of the dual system and in 2000 this figure was 1.7 million, the highest recorded since unification (BIBB 2019, p. 110). In its core, the dual system is regulated by a training market in which companies offer training places and (mostly) young people decide whether they apply for a training place or not. Therefore, supply and demand need to meet for new training contracts to emerge. The development of supply and demand figures provide a good indication of the quantitative development of the training market over time, which shows a cyclical nature. This, in turn, is linked more or less closely to the overall economic cycles. While in periods of stable economic growth the number of training contracts tends or increase, economic crises often lead to sharp decreases in numbers. Figure 2 presents the development of the three key figures in the training market since German unification: the supply of training places, the demand for places and the number of newly conducted training contracts.

Figure 2: Number of new training contracts, demand and supply in the dual system of VET in Germany since 1992



Source: Own representation based on BMBF 2024

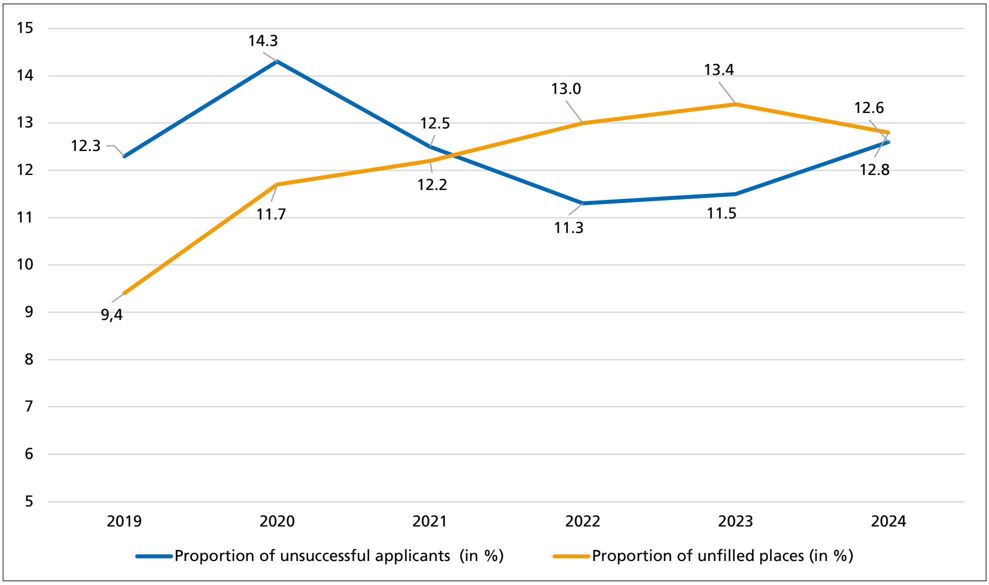
For the more recent periods, there were sharp decreases for all three key figures in the wake of financial crisis of 2008/2009 and the Covid pandemic of 2019/2020. In 2020, the number of new contracts fell under half a million for the first time since unification. In both cases, the supply of training places fell sharply by between 8.5 and 9 percent with demand being reduced by almost the same margin. After both crises, the recovery of the training market was slow and remained partial, stabilising at a much lower plateau.

In 2023, the share of new contracts with women was 36.1 percent. This proportion has been decreasing slowly but steadily over time (2009: 42.9 percent) reflecting the relative growth of training that is conducted outside the dual system. This includes sectors that are traditionally more popular with women, such as care, health, and education (BIBB 2024).

The average age of new trainees was 20.0 years in 2022, increasing slightly over recent years (2009: 19.4) (BIBB 2024).

Arguably more significant than the absolute number of new training contracts is the number of cases in which supply of training places cannot be matched with the demand for training; a phenomenon that is not clearly identifiable in Figure 2. In order to do so, the number of training places that cannot be filled and the number of unsuccessful applicants need to be considered. These figures show an increase in the number of training places that remain unfilled, rising to 69,400 training places in 2024. At the same time the number of applicants who cannot find a training place has remained at a high level (70,400 in 2024) (Weller et al. 2024). Figure 3 illustrates these developments as proportions of unfilled places and unsuccessful applicants in relation to the total number of offered places and applicants. In 2024, 12.8 percent of all training places offered remained unfilled (2009: 3.7%) and 12.6 percent of applicants were not able to secure a training place (2009: 12.6%).

Figure 3: Proportion of unsuccessful applicants and unfilled places in the dual system in Germany since 2009 (in %)

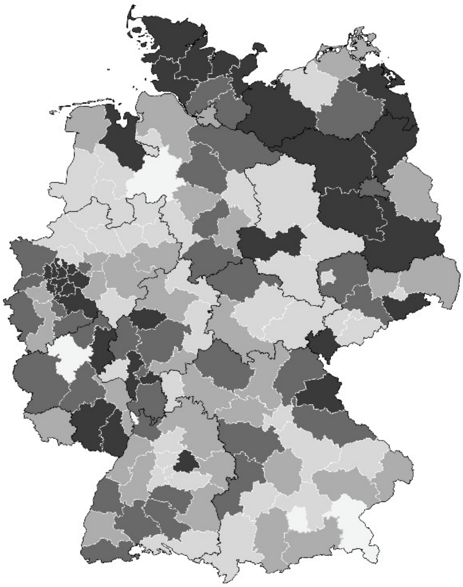


Source: Own representation based on Weller et al. 2024

This phenomenon is unusual as in previous phases of strong economic growth training companies offered more training places which, in turn, resulted in a reduction of unsuccessful applicants. In recent years, however, there seems to be a growing mismatch between supply and demand. On the one hand, companies who are looking for trainees cannot fill their places because they do not receive any applications or they regard applicants as unsuitable for the training offered. On the other hand, young people interested in training apply for training places in areas that are highly competitive or they are not regarded suitable because of factors such as their educational background. It should also be mentioned that the training market is highly regionalised, with some parts of Germany suffering from undersupply of training places (for instance, in the former industrial heartlands of the Ruhr-Valley), other parts from a lack of sufficient numbers of people interested in training (for instance, in the economically booming region of southern Bavaria), and areas in which both phenomena can be observed (particularly in eastern Germany).

The map in Figure 4 shows the BIBB “Mismatch Index” applied to the regions of Germany: The darker a region is on a map, the more both phenomena (high proportions of unfilled places and of unsuccessful applicants) occur at the same time.

Figure 4: Mismatch Index in German Regions 2017



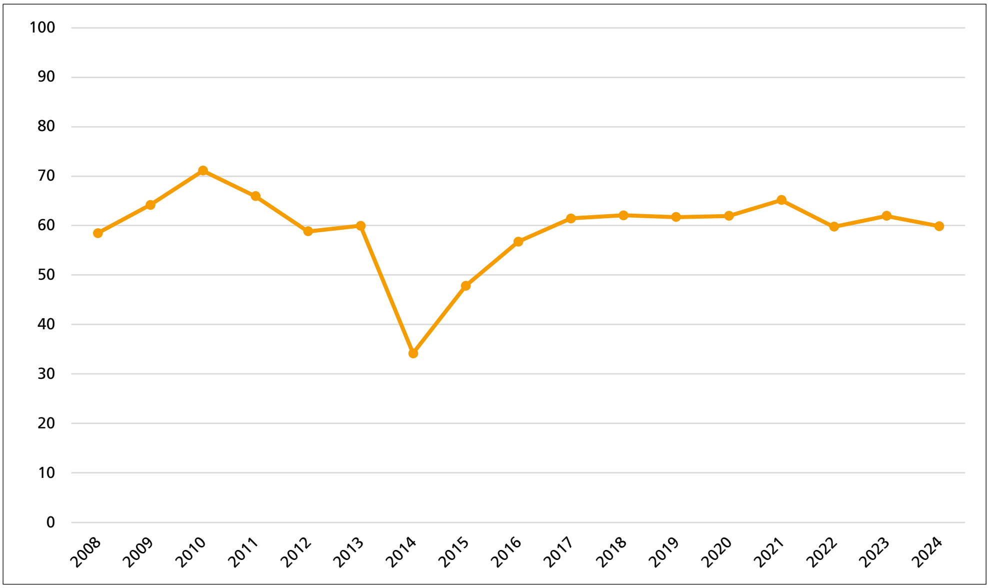
Mismatch Index	< 50	50 – u. 100	100 – u. 150	150 – u. 200	> 200
Number of Regions 2017	5	41	34	35	33

Source: Federal Institute for Vocational Education and Training, survey as of September 30; Federal Employment Agency, training market statistics as of September 30 (special evaluation in preparation for the vocational training report)); Federal Institute for Vocational Education and Training, own calculations by department 1.1. © GeoBasis-DE/BKG 2017 (data modified). Visualization of employment agency districts: Federal Institute for Vocational Education and Training (BIBB)

The mismatch in supply and demand on the training market and the demographic trend of shrinking youth cohorts (Autorengruppe Bildungsberichterstattung 2024) feed into the widely-discussed problem of skilled labor shortages in Germany. The unexpectedly high influx of mainly young refugees in 2015 and 2016 has boosted participation in vocational training (BIBB 2019, p. 331) but has not prevented the significant growth in the number of unfilled training places. While the automatization of production and service processes reduces the number of jobs in low-skilled sectors of the economy, digitalisation results in the need for a more highly skilled workforce at the same time (Zika et al. 2017; 2018). In combination with changing educational preferences in society, this has led to growing participation in higher education, particularly between 2000 and 2010 (Autorengruppe Bildungsberichterstattung 2024)

In **Wisconsin**, in more recent years from 2016 to 2022 about 62 percent of apprentices who exited their apprenticeship, successfully completed their apprenticeship.

Figure 5: Wisconsin Registered Apprenticeship Completion Rate by Year (in %)



Completion rates were calculated taking number of completed registered apprenticeships divided by total apprenticeship exits (completed plus canceled) in a year.

Source: Own representation based on Apprenticeship Resources and Data by the Department of Workforce Development Wisconsin[8]

Completion rates are strongly linked to wage and employment gains. For instance, completers earned nearly $9,550 more per quarter post-exit and were 25 percent more likely to be employed.

8 See URL: **https://dwd.wisconsin.gov/apprenticeship/facts-data.htm** (Retrieved on 02.12.2025).

Completion rates vary widely by trade. For example, completion rates by standard occupation classification (SOC) installation, maintenance and repair occupation = are over 75 percent, whereas the rates in personal care and service occupations are around 30 percent. The following table looks at completion rates by trade for the most common registered apprenticeships in 2016 to 2022.

Table 2: Most Common Wisconsin Registered Apprenticeship Trades 2016 to 2022: Completion Counts, Completion Rate, Wages Two Quarters after Exit for Completers, and Average Time to Completion

Trade	Number Completed	Completion Rate	Two Quarters after Exit Average Wages[9]	Average Time to Complete (in years)
Plumber/Pipefitter/Steamfitter	1,715	67%	$24,173.29	5.05
Electrician	1,700	61%	$21,505.91	4.84
Operating Engineer or Construction Equipment Operator	1,252	78%	$23,048.44	2.74
Carpenter	1,018	56%	$18,534.48	4.00
Electrical Power-Line Installer/ Repairer	622	86%	$32,200.71	3.26
Sheet Metal Worker	499	73%	$21,250.15	5.00
Millwright	465	76%	$22,459.91	4.00
Industrial Machinery Mechanic	457	76%	$21,723.71	3.85
Tool and Die Maker	413	77%	$18,362.30	3.88
Construction Laborer	411	36%	$16,652.82	2.85
Structural Iron and Steel Worker	348	54%	$17,962.58	3.89
Machinist	344	70%	$17,960.74	3.60
Firefighters	292	70%	$19,846.51	3.25
Heating, Air Conditioning, and Refrigeration Mechanic/ Installer	229	67%	$21,538.39	4.40
Maintenance and Repair Worker	215	62%	$22,351.63	4.59

Source: Own Representation based on Apprenticeship Resources and Data[10]

9 These wage amounts are for one calendar quarter (six months after exiting the apprenticeship). To estimate annual wages multiply these values times four.

10 See URL: **https://dwd.wisconsin.gov/apprenticeship/facts-data.htm** (Retrieved on 11.11.2025).

Apprentice demographics are predictive of completion even when apprentice trade is accounted for with women, non-white apprentices, those with disabilities, and those living in urban areas significantly less likely to complete their apprenticeships. Staff use completion rate data to inform technical assistance to better support higher completion rates across trades and demographics. Wisconsin actively tracks race, gender, disability, and veteran status. For example, apprentices with disabilities who co-enroll in vocational rehabilitation earn up to $1,000 more per quarter. These insights guide program design and policy that works better for everyone.

4 Labor Market Analytics and Skills Shortages

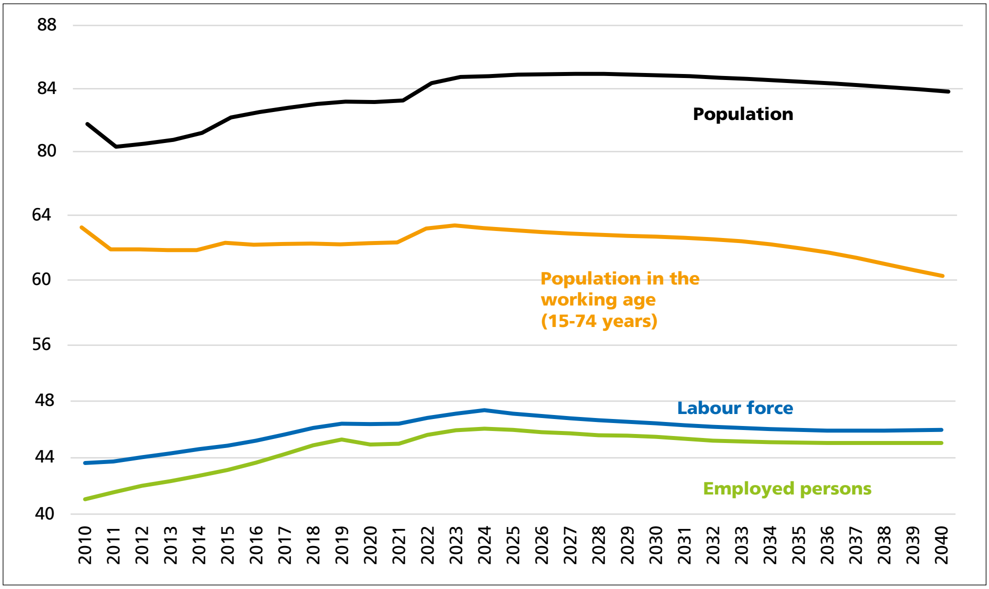
The Federal Employment Agency of **Germany** analyses labor market data systematically and publishes figures on labor market shortages retrospectively. In this context, the Agency uses the classification for occupations, consisting of a total of 1,236 occupations at 3 different levels (occupations requiring initial training, specialized training, or high-level expertise). According to the figures, the number of shortage occupations reached its peak in 2022, when there was a shortage in 200 occupations, rising from 131 in 2020 and 148 in 2021. Mainly due to declining labor demand as a result of a slowdown in the German economy, shortage numbers decreased to 183 occupations in 2023 and 163 in 2024. The Agency highlights the following occupational areas as most affected by shortages in 2024: occupations in the care sector, the medical sector, construction and handicrafts, IT and hospitality (BA 2025).

In order to implement measures to counteract current skilled labor shortages and to prevent future ones, it is important to establish reliable predications of supply and demand of skilled labor in the future. For this purpose, the BIBB has conducted labor market projections in collaboration with the Research Institute of the Federal Employment Agency (IAB) and the Institute of Economic Structures Research (GWS). The aim of the projections is to provide a long-term overview of the expected development of workforce demand and supply broken down by qualifications and occupations. The key strengths of the projections are the consideration of occupational mobility, the use of a harmonised data set of National Accounts, microcensus, employment histories, and the calculation of scenarios.

Some of the key baseline figures resulting from the analysis of existing data and future projections are summarised in Figure 6:

- the overall population will start to decline from 2026 and will be nearly one million lower in 2040 (as compared to 2023),
- the population at working age will decline by around 3.1 million people from 63.4 million in 2023 to 60.3 million in 2040,
- due to the increase in the labor force participation rates of women and older people, the decline in the labor force is lower (-1.12 million) than the decline of population at working age,
- the number of people in employment is also falling (-0.90 million).

Figure 6: Overview of demographic and labor market development in Germany



Source: Maier et al. 2024, depiction adapted and translated by authors

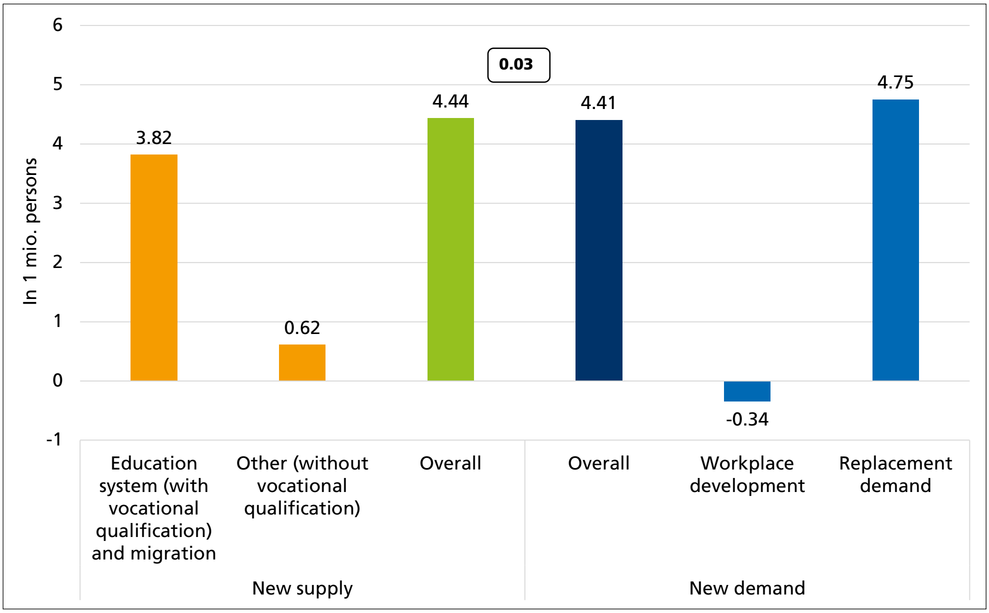
Based on the data feeding into the macro-economic model, more specific projections for the medium-term development of the labor market can be developed. In this way, labor market entries and exits can be projected.

Labor market entries consist of graduates from different parts of the education and training system (with or without formal qualification) as well as the net migration surplus (more people migrating to Germany than people moving away from Germany). In Figure 7, the projections for labor market entries are shown on the left in blue columns, summarised as "new supply".

Labor market exits consist of people entering retirement (replacement demand) and of the change of the number of jobs overall (workplace development). For the period 2024 to 2028, the model projects a reduction of 340,000 jobs, mainly due to the weak expected development of the German economy over this period. In Figure 7, the projections for labour market exits are shown on the right in green columns, summarised as "new demand".

The result of the projections for the period 2024 to 2028 shows that entries to the labor market will outweigh exits by about 30,000. This means that despite expected job cuts, supply and demand for labor will remain more or less balanced over the next five years. This marks a reversal of recent trends, when demand outstripped supply significantly. While for the moment the weakness of the German economy has reversed this, the expectation in the longer run is that there will be a (continued) shortage of supply, particularly in the segment of skilled labor. Given the demographic decline of the German population, attracting qualified migrants has become a key aim of economic planning and policy (Maier/Kalinowski/Krinitz 2024).

Figure 7: Development of overall labor market flows in Germany, 2024 to 2028

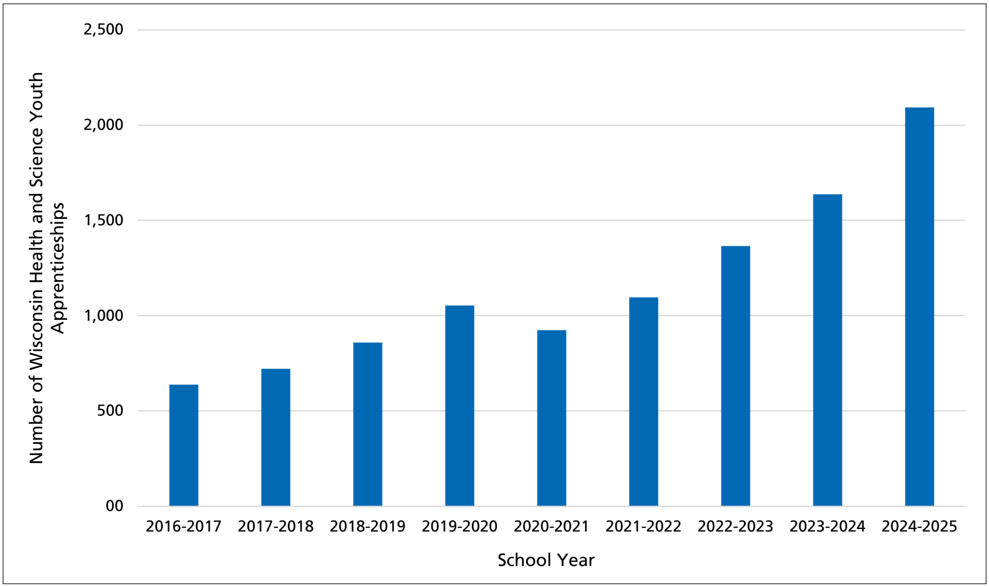


Source: Zika et al. 2024, depiction adapted and translated by authors

Wisconsin's DWD uses labor market forecasts to identify "hot jobs" – occupations with high demand, growth, and wages. One Wisconsin online resource demonstrates "hot jobs" incorporated in career pathways across multiple career clusters, including health and science[11]. Targeted apprenticeship growth in healthcare and education addresses these gaps, as seen in the rise of youth health science apprentices from 550 in 2015 to over 2,000 in 2024.

11 URL: **https://www.jobcenterofwisconsin.com/wisconomy/pub/wda-pathway-all.htm** (Retrieved on 29.08.2025).

Figure 7a: Total Participating Wisconsin Youth Apprenticeships in Health Science by School Year

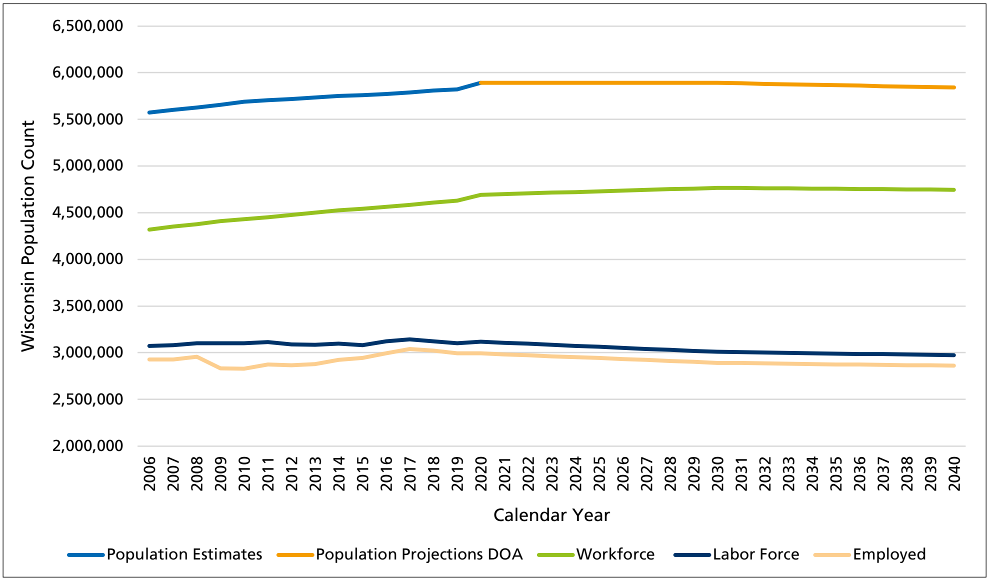


Source: Own Representation based on Wisconsin Youth Apprenticeship Student Participation Dashboard[12]

Labor market information (LMI), such as industry and occupation projections, provide guidance to employers, students, and training providers about growing sectors with job demand. Thus, helping employers identify training needs, students chose a career, and trainers design training programs. Data from training institutes and apprenticeship further provide employers with additional information on opportunities to train a skilled workforce. Using DWD's demand-side projections and labor supply analysis, DWD staff found a labor a supply gap (Winters et al. 2024). Updated analysis of this paper identified a shortage in Wisconsin of labor to fill nearly 292,000 jobs in 2032. If current trends are carried forward, this shortage will increase, as retirements continue to exceed Wisconsin residents aging into the workforce.

12 Data retrieved from **https://dwd.wisconsin.gov/apprenticeship/ya/yoda.htm** on 29.08.2025.

Figure 8: Projected Demographic changes in Wisconsin

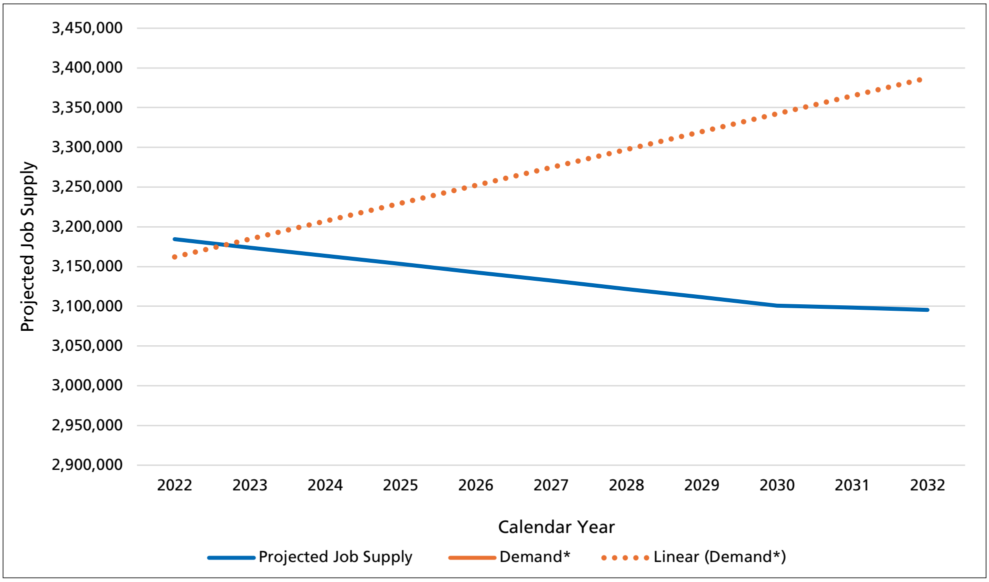


Source: Own Representation of Population Estimates from Census and Population Projections based on Wisconsin Department of Administration[13]

- The overall population will start to decline from 2020 will be more than 52,000 lower in 2040 (as compared to 2020),
- Although population at working age will not decline due to decrease in institutionalization rates but the increase is very small.
- Decline in labor force participation rates especially in 16–19 years olds (Winters et al. 2024) expected to lead to a decline of 143,607 in 2040 (as compared to 2020).
- Similar decline will be seen in employed people with 132,373 less in 2040 compared to 2020.

13 See URL: **https://doa.wi.gov/Pages/LocalGovtsGrants/Population_Projections.aspx** (Retrieved on 29.08.2025).

Figure 9: Supply Demand Gap analysis for Wisconsin



**DWD long term occupation projection numbers are used as comparison/demand*

Source: Own Representation based on Occupation Projections[14]

State industry projections highlight growth in certain sectors, providing more detailed information on skilled job demands in specific trades and occupations[15]. For example, Wisconsin's DWD LMI staff provide a report on forecasting the supply and demand of nursing[16]. The registered nursing (RN) occupation shows a gap in nursing supply both in the present and future to meet the demand of Wisconsin's healthcare service needs. Current data show a nursing shortage in 2022 of 4.3 percent. The model projects a flat supply with a rapidly increasing demand. With this model, the estimated gap between RN supply and demand will increase to 25.8 percent by 2040. To help meet this increasing demand, multiple apprenticeships in the healthcare pathways have been established in Wisconsin aimed to narrow the supply demand gap. For example, youth apprentices in health sciences have increased from 550 in the 2015–2016 school year to 2,093 in the 2024–2025 school year[17]. At the same time, a new RN and other healthcare registered apprenticeships have been developed[18].

14 See URL: **https://www.jobcenterofwisconsin.com/wisconomy/pub/occupation** (Retrieved on 29.08.2025).
15 See URL: **https://www.jobcenterofwisconsin.com/wisconomy/pub/industry.htm** (Retrieved on 29.08.2025).
16 See URL: **https://www.jobcenterofwisconsin.com/wisconomy/wits_info/downloads/projections/nurses-survey-2024.pdf** (Retrieved on 29.08.2025).
17 See URL: **https://dwd.wisconsin.gov/apprenticeship/ya/yoda.htm** (Retrieved on 29.08.2025).
18 See URL: **https://dwd.wisconsin.gov/apprenticeship/industry/healthcare.htm** (Retrieved on 29.08.2025).

Another trade or occupation area with increases in labor supply demand is education. Wisconsin county profiles listed limited and costly childcare as a barrier to work for parents with young children[19]. Staff analysis of both early childhood and school age education occupation and industry projections show a shortage of childcare workers reducing the supply of needed childcare, as well as a shortage of school-age teachers. These analytics led to new Wisconsin apprenticeships in both early childhood and school age education[20].

Apprenticeships can address labor supply shortages more quickly than higher education pathways. Employers can quickly higher employees and train apprentices on the job, tailoring instruction on work learning experiences to align with skill need. With Wisconsin's unique state apprenticeship law, most employers in Wisconsin pay apprentices for both on-the-job work and related instruction, a benefit unique to Wisconsin. Wisconsin apprentices can find a job quicker and earn a paycheck while training and studying, earning a higher income than they can likely accrue if they paid for a traditional educational degree with no guarantee of related work experience[21].

Rather than outsourcing jobs, apprenticeships provide a cost-effective way to help local companies and organizations close workforce gaps, reduce turnover, and increase productivity. According to a United States Department of Labor report, an employer receives 44.3 percent return on their investment (ROI) in registered apprenticeship in both direct and indirect costs. Thus, for every dollar invested, the employer earns $1.44. in benefits (Kuehn et al. 2022). Apprentices also benefit from an apprenticeship. U.S. DOL reported that of the apprentices who complete their apprenticeship, 94 percent retain their employment long term, earning an average of $70,000 annually[22]. Because apprenticeships are mainly voluntary, Wisconsin employers can use these study results and data analytics to inform their decisions to start and/or continue additional apprenticeships to fill skilled workforce needs.

5 Conclusion

Germany and Wisconsin illustrate the power of data-driven apprenticeship policy in differing contexts. Germany's nationally structured and regulated framework contrast with Wisconsin's pragmatic, outcome-focused analytics. Both systems show the importance of robust data, equity-centered design, and responsive policy for strengthening workforce readiness in the face of demographic and technological change.

The juxtaposition of the overviews of data relating to VET in the contexts of Wisconsin and Germany has demonstrated that the type of data collected, its analysis and its potential use is closely bound to historical and legal factors. Both jurisdictions are characterised by a

19 See URL: **https://jobcenterofwisconsin.com/wisconomy/pub/profiles** (Retrieved on 29.08.2025).

20 See URL: **https://dwd.wisconsin.gov/apprenticeship/ya/become-youth-apprentice/education.htm** (Retrieved on 29.08.2025).

21 See URL: **https://www.dwd.wi.gov/apprenticeship/pdf/build-future-apprenticeship.pdf** (Retrieved on 29.08.2025).

22 See URL: **https://www.apprenticeship.gov/sites/default/files/Apprenticeship_Fact_Sheet.pdf** (Retrieved on 29.08.2025).

federal structure in which federal, state and regional levels interact; this also has an impact on relevant VET data and its use. However, the German and the US models of federalism are structured very differently, which further complicates comparisons.

Nevertheless, in both jurisdiction the relative size of the VET sector as well as the constituent parts of the sector are an important concern for data collection, allowing for monitoring the quantitative development of the VET sector and its subsectors. Also, the role of VET in producing skills required by the labor market is an important theme driving the development of data systems in Wisconsin and Germany. In both systems increasing efforts are made to link VET data with data on labor market outcomes in order to be able to assess the effect of training approaches and programmes and to track career developments of individuals over time.

In future, it will be important to develop and implement strategies that can counteract the trend of decreasing response rates in surveys. This trend affects surveys of applicants, of participants of training and of training companies alike. The use of data that is not specifically generated for research purposes will become more important, as will the linking of different data sources. Wisconsin's use of administrative data helps to continue to track program, and labor tends even when survey response rates decrease. Enhancing administrative data collection could improve the quantity and quality of data available policy-based decision-making. For example, enhanced unemployment insurance (UI) wage records could provide a mechanism to better track location of jobs, hours worked, pay rate, and occupation (US BLS 2022). In Germany, the discussion on the introduction of an "Education ID", allowing to follow learners' progression through all stages of training and education and into the labor market, is gathering pace. All this will be crucial for generating data that will allow us to provide evidence-based policy advice in the future.

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Evidence-Based and Data-Driven Knowledge Transfer Strategy: 7 Steps

This paper describes the real case – the approach used for creation of a Knowledge Transfer Strategy (KTS) for two schools of vocational education and training (VET) in Ukraine in terms of their transformation into the Centres of Vocational Excellence (CoVEs). The presented KTS approach offers a structured, evidence-based framework grounded in a Theory of Change. The described guidance outlines a seven-step process – from strategic visioning and institutional assessment to role mapping, implementation, and sustainability planning. It emphasises collaboration, capacity-building, and alignment with labour market needs while fostering mutual learning through clearly defined KT roles. Survey data and KT role mapping provide actionable insights that help align institutional development with national VET policy objectives and guide strategic decision-making. The key focus is on implementing practical mechanisms such as Erasmus+ participation, mutual knowledge and practices exchange, joint interventions, and phased implementation to ensure long-term impact and scalability.

1 Introduction

Ukraine's labour market (LM) is undergoing a profound transformation as the country navigates the dual pressures of war-related disruption and long-term demographic shifts.[1] As of December 2024, approximately 3.7 million people remain internally displaced (IDP), with 24 percent of newly IDPs unemployed, nearly double the 13 percent unemployment rate among long-term IDPs (IOM 2024). Labour shortages are now a critical bottleneck: 26.7 percent to 36 percent of businesses report difficulties filling vacancies, driven by conscription, emigration, and skill mismatches, with 16 to 18 percent of jobseekers lacking required qualifications.

Employers are adapting rapidly – engaging women in non-traditional roles, recruiting students and retirees, and offering on-site and fast-track training, especially in sectors like construction. At the same time, Ukraine's government is intensifying efforts to reform VET. The Ministry of Education and Science (MoES) supports updating curricula, promoting public-private partnerships (PPP), and enhancing training quality, while international partners such as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, the International Organization for Migration (IOM), the European Bank for Reconstruction and Development (EBRD), and the United Nations Development Programme (UNDP) support large-scale reskilling programmes for IDPs and small and medium enterprises (SMEs).

1 AI was used to make the text more reader-friendly and avoid sharing the sensitive information (between August 18th and 20th).

A 2024 tracer study of 18,979 VET graduates offers key insights into VET-work transition. Overall, 68.3 percent of graduates are employed, with 89 percent working in Ukraine and 79 percent of those aged 20 to 23 holding stable jobs. Gender disparities remain significant, with 74.5 percent of men employed compared to 62.7 percent of women. While 62.3 percent work in their trained profession and 87.6 percent regularly apply acquired skills, job relevance declines among older graduates. The war continues to affect employment outcomes – 49 percent report negative impacts, and 29.6 percent of graduates aged 23+ consider seeking work abroad. Skill gaps persist, particularly in stress resilience (41.7%), regulatory knowledge (21.8%), and client service (20.3%). VET infrastructure remains challenging with inadequate equipment (14%) and very poor dormitory conditions (10%).

Despite data limitations due to wartime disruptions, LM forecasting continues using alternative sources – State Employment Service (SES) vacancies, employer surveys, and assessments by the International Labour Organization (ILO), GIZ, Helvetas and IOM. Artificial Intelligence (AI) and machine learning are beginning to inform LM predictions. Better alignment of VET with employer needs through tools like the National Qualifications Framework (NQF) – already compared with the European qualification Framework (EQF) (European Commission 2023) – is already in place.

Donor-supported initiatives – such as EU4Skills, Skills4Recovery, EdUP, Economic Recovery Programme (ERP), the Skills Alliance (aiming to retrain 180,000 individuals by 2027) etc. – are helping Ukraine "keep a finger on the pulse" of workforce development (WFD) demand. They emphasize lifelong learning, adult upskilling, and integration of vulnerable groups, including women, IDPs, and youth.

In this evolving context, data-driven knowledge transfer (KT) becomes essential. Ukraine can learn from international examples e.g. Germany's dual education system, South Korea's tripartite industrialization model, Singapore's SkillsFuture, Finland's inclusive VET reform, Poland's EU-backed labour transition etc. Applying such insights can help Ukraine build a resilient, modern, and inclusive WFD strategy (Leu-Severynenko 2024).

The following section presents a 7-step evidence-based and data-driven KTS, grounded in Ukraine's current context and informed by best practices from Eastern Partnership (EaP) and the countries of the European Union (EU). As EaP countries, including Ukraine, work to transform their VET systems through CoVEs development, structured international knowledge exchange has become a key driver of progress. Peer learning through study tours, conferences, and educator exchanges allows reflection on models like dual education, continuous teacher training, sectoral specialization, and quality assurance – and tailor them to local needs. Early and sustained cross-border collaboration strengthens institutional capacity and lays the groundwork for long-term regional leadership in skills development. The KTS outlined here serves as a practical roadmap to guide VET schools through this transformation, built on data, strategic partnerships, and shared expertise.

2 Methodology

KTS can be developed using a **Theory of Change (ToC)** framework. ToC's clear, logical structure built on the sequence of IF-THEN-BECAUSE helps link activities with intended outcomes, making assumptions visible and testable (Salib 2022). This approach strengthens the strategic focus, transparency, and measurable impact of KT interventions. The strategic use of survey data and visual tools supports evidence-based planning.

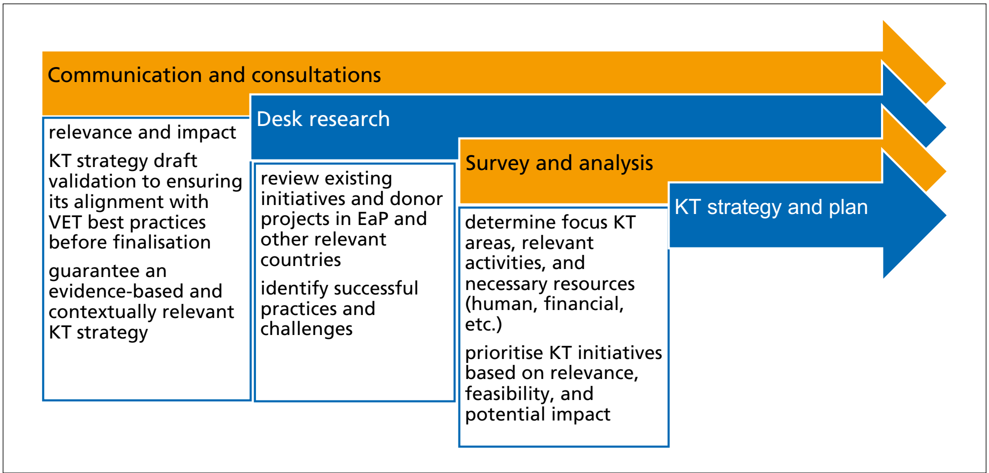
The overall process of creating the evidence-based and data-driven KTS may include:

- **Selection of targeted institutions** involves the purposive identification of VET schools based on criteria such as training profiles, existing collaboration readiness, and alignment with national reform priorities.
- **Survey and interviews** are conducted with CoVEs/TVETs from targeted countries to gather structured qualitative and quantitative data on institutional strengths, challenges, cooperation potential, and preferred KT areas (KTA). These tools use a combination of closed Likert-scale items, multiple choice and open-ended questions to capture both priority ratings and narrative input. The "Other" options are offered to open separately to collect more insights and ideas that may be missed in the survey.
- **Data analysis** includes frequency analysis of prioritized KTAs, cross-tabulation of institutional characteristics and KT role preferences, and clustering of thematic needs. Descriptive statistics are used to identify trends across institutions, while heat maps or priority matrices may be applied to visualize role mapping outcomes.
- **Key Indicators** used in the analysis include the *number of institutions* prioritizing specific KTAs (e.g., WBL, quality assurance), *institutional readiness* scores (based on self-assessment), *willingness to share* (measured through role selection frequency and qualitative justification) and the degree of *alignment with sectoral or national priorities*.
- **KTA Prioritization** is done using a weighted scoring system that incorporates urgency, institutional demand, and potential for cross-border cooperation.
- **Role Mapping** assigns KT roles – **Receiver (R), Provider (P), Contributor (C), and Exchanger (E)** – to each institution based on triangulated survey data, interviews, and validated self-assessments.
- **Implementation Plan** is developed based on these inputs, ensuring alignment with transformation goals, institutional capacity, and expected outcomes. It includes milestones, timelines, and a realistic budget covering capacity-building, mobility, technical assistance, and sustainability measures.

Regular communication loops and review checkpoints are integrated into the process to allow for feedback-driven adjustments, ensuring responsiveness to stakeholder expectations and emerging opportunities. Flexibility is essential to update priorities and interventions as new data becomes available or contexts shift.

The overall framework of the described methodology is given in Figure 1.

Figure 1: Knowledge for Creating a Transfer Strategy Methodology



Source: Created by the author

3 Step-by-Step Instructions

Each step contributes to building a VET system that is better informed, more coordinated, and aligned with real needs on the ground. KTS thus serves not only institutional transformation but also systemic policy development across the targeted region(s).

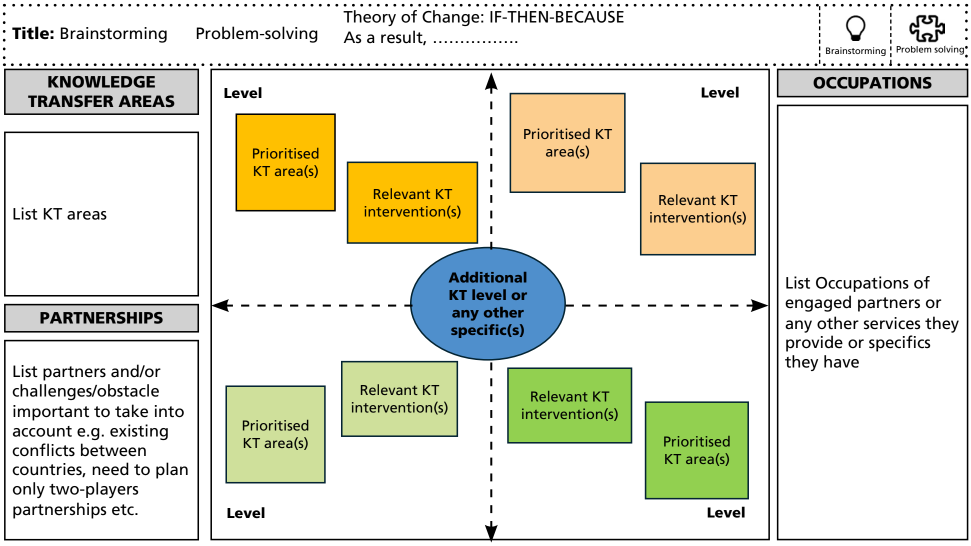
3.1 STEP 1: DEFINE STRATEGIC VISION AND OBJECTIVES

- Clarify the transformation goals of the VET school into a CoVE.
- Align with national and regional VET priorities and the needs of employers in general or partner companies of a targeted VET school.

The in-between step can be collecting feedback for the visualized framework from involved stakeholders and decision-makers to ensure maximum alignment of the offered approach with the priorities and desired components they want to see in the final KTS (Salib 2022). An example of the visualized framework is given in Figure 2.

Policy relevance: A well-defined vision and objectives aligned with national priorities ensure that institutional transformation supports broader reform goals and feeds into regional and national VET development plans (ETF 2020).

Figure 2: The Framework of Knowledge Transfer Strategy



Source: Created by the author at the Microsoft Whiteboard Application (Icons: Lightbulb: https://icons.getbootstrap.com/icons/lightbulb/; Puzzle: https://icons.getbootstrap.com/icons/puzzle/)

3.2 STEP 2: CONDUCT INSTITUTIONAL and ECOSYSTEM ASSESSMENT

- Use the survey tool to assess internal capacities, partnerships, and KT readiness.
- Map relevant stakeholders, including industry, government, and peer institutions.

The survey should include a sufficient number of questions, including "other" options where needed. This allows for a more detailed understanding of practical conditions and identifies specific needs or gaps not captured in predefined categories. Include options for respondents to indicate if they "have strong expertise but are not willing to share". These "red flags" can guide future trust-building actions and targeted dialogue (IMD 2023).

Policy relevance: The assessment results can inform local and national VET policy by highlighting institutional strengths and weaknesses, guiding policy adjustments, resource allocation, and support mechanisms.

3.3 STEP 3: IDENTIFY KNOWLEDGE TRANSFER PRIORITIES

- Use evidence from surveys/interviews to rank KTAs such as: CoVE management, Work-based learning (WBL), Digitalisation, Curriculum modernization, Teacher development, Quality assurance etc. (ETF 2021; ETF 2025).

Thorough data analysis at this stage ensures that the KTS is grounded in evidence and reflects the real challenges and opportunities identified by stakeholders. Any “red flag” areas can be followed up for clarification and building confidence. Use a summary table (e.g. Table 1) to document challenges and proposed solutions.

Policy relevance: The identification of KT priorities provides a roadmap for policymakers to develop targeted interventions that address specific institutional gaps and align with systemic development strategies.

Table 1: Support mechanisms targeting

Challenge	Support Type	Recommendation
Challenge 1	Support type 1	Recommendation 1
	Support type 2	Recommendation 2
Challenge 2	Support type 3	
Challenge X	Support type 4	Recommendation X
Challenge XX	Support type 5	
Challenge XXX	Support type X	

Source: Created by the author

3.4 STEP 4: ASSIGN KNOWLEDGE TRANSFER ROLES

- Determine each institution’s role (R/P/C/E) per KTA.
- Map these roles to build complementary partnerships.

KT roles help structure, facilitate, and sustain KT between engaged players. They help avoid duplication, focus resources, ensure mutual benefit, and transform KT into a strategic driver of vocational excellence (VocEx) development. The roles for KTS for CoVEs/TVETs may include:

- Knowledge Receiver (R) – benefits from external expertise and support;
- Knowledge Provider (P) – shares proven practices and innovations;
- Knowledge Contributor (C) – develops and contributes knowledge content;
- Knowledge Exchanger (E) – shares and learns collaboratively.

Developing a KT role matrix per area (e.g. Tables 2 and 3) encourages institutions to reflect on their capacities and build well-matched partnerships. This aligns with the EaP framework for CoVEs, which encourages institutions to act as knowledge exchangers, providers, and contributors (ETF 2020; IMD 2023).

Policy relevance: Role mapping supports coordinated capacity development across institutions and enables ministries or national agencies to identify strong candidates for leading sector-specific KT efforts.

Table 2: KT roles matrix for one partner

KT Areas/Levels	XX	XX	XX	XX
CoVEs management	ER		ER	ER
....	ER		ER	
Digitalisation	EC		PER	
....	ER	CE	ER	
Work-based learning (WBL)	ERC	CP	CPER	ER
....	ERC		CP	CPER
....	ERC	CP	CP	CPE
....				R

Source: Created by the author

Table 3: KT roles matrix for several partners

Partner/Role	Knowledge Receiver	Knowledge Provider	Knowledge Contributor	Knowledge Exchanger
Partner 1	Relevant KT areas (KTA)	Relevant KTAs	Relevant KTAs	Relevant KTAs
Partner 2	Relevant KTAs	Relevant KTAs	Relevant KTAs	Relevant KTAs
Partner XX	Relevant KTAs	Relevant KTAs	Relevant KTAs	Relevant KTAs

Source: Created by the author

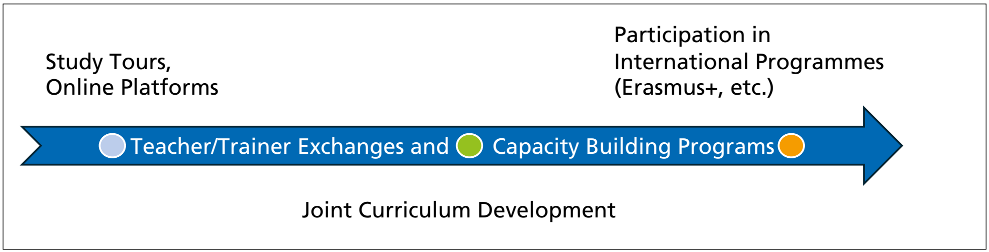
3.5 STEP 5: DESIGN KT MECHANISMS

- Select effective mechanisms based on institutional needs: study tours, twinning arrangements, teacher/trainer exchanges, joint curriculum development, online platforms, Erasmus+, and regional programmes.

KT mechanisms should be phased to build trust and engagement early (e.g., study tours), then progress toward co-creation (e.g., curriculum development). Platforms to match institutions with EU CoVEs should be developed to streamline collaboration (ETF 2025). An example of the efficient use of collaborative mechanisms is given in Figure 3.

Policy relevance: Successful KT mechanisms serve as pilot models that can inform national-level frameworks for VET partnerships and internationalization strategies.

Figure 3: Collaborative mechanisms



Source: Created by the author

3.6 STEP 6: PLAN PHASED IMPLEMENTATION

- Short-term (6 months) to establish partnerships, define priorities, align plans
- Medium-term (12 months) to launch pilots, implement capacity-building, run exchanges
- Long-term (6 months+) to evaluate outcomes, develop sustainability roadmap, scale success

Phased implementation supports adaptability and allows for lessons learned to shape future actions (Salib 2022).

Policy relevance: Well-documented phased implementation offers a scalable model that can inform national rollouts or funding allocation decisions across the VET system.

3.7 STEP 7: DEVELOP SUSTAINABILITY AND FUNDING PLAN

- Integrate KT into institutional strategies
- Identify funding sources (Erasmus+, national grants, PPP etc.)
- Institutionalize KT teams and create support structures for ongoing partnerships

Sustainability planning helps embed KT within institutional culture and ensures long-term collaboration.

Policy relevance: Institutional sustainability frameworks provide evidence for continued public investment and inform long-term policy commitments to KT-enabled VocEx.

4 General Recommendations

Applying ToC ensures alignment with institutional transformation goals, while tailoring interventions and fostering mutuality enhances relevance and engagement. Emphasizing evidence-based planning, employer involvement, and phased collaboration builds trust and long-term impact. Leveraging regional models and international programmes (e.g. Erasmus+ etc.) further strengthens sustainability and scalability across the targeted region(s) (ETF 2020; ETF 2025). So, to design the effective, context-sensitive KTS it is recommended to:

1. *apply the Theory of Change* to ensure that all KT activities clearly contribute to institutional transformation goals;
2. *tailor KT interventions* based on institutional readiness and sectoral needs; avoid one-size-fits-all approaches;
3. *foster mutuality* in partnerships by clearly identifying each institution's capacity to contribute and receive;
4. *strengthen evidence-based decision-making* through systematic data collection and impact tracking;
5. *build ownership and trust* through phased engagement – starting with light-touch exchanges and progressing to joint development;
6. *leverage international programmes* like Erasmus+ to fund and anchor long-term strategic collaboration;
7. *engage employers* early and actively to align KT with LM needs and co-develop curriculum, internships, and innovation projects;
8. *use regional models* (if any) to promote scalable practices across institutions and countries;
9. *use digital tools or platforms* (e.g., dashboards, survey software, visual analytics) to manage and visualize the data.

5 Conclusions

To effectively address Ukraine's WFD challenges and drive sustainable recovery, a strategic, data-driven reshaping of the VET system is essential. Central to this transformation is the development of CoVEs, which will serve as integrated hubs connecting education, industry, and innovation. Embedded within broader reform efforts – such as expanding demand-driven programs, modernizing infrastructure, reintegrating IDPs, and enhancing lifelong learning and career services – CoVEs can help build a more agile and inclusive WFD ecosystem. Informed by LM intelligence, graduate feedback, and international collaboration, they ensure continuous alignment between VET provision and evolving economic needs, positioning them as key drivers of high-quality, employment-oriented education.

The proposed KTS reinforces the critical role of structured knowledge exchange in enhancing the relevance and adaptability of VET – particularly during periods of transformation and recovery. By fostering peer learning and collaboration, knowledge transfer becomes a strategic mechanism for integrating best practices, strengthening curricula, and aligning training with LM market demands. It also promotes meaningful cross-country dialogue to support the design, implementation, and scaling of CoVEs.

Structured exchange activities – such as study tours, teacher and manager exchanges, and international workshops – serve as instruments for capacity building and long-term institutional partnerships, allowing stakeholders to benefit from shared experiences at different stages of CoVE development. The use of an evidence-based, phased methodology ensures these interventions remain context-sensitive, scalable, and impact-oriented.

Importantly, KTS offers a transferable framework that can be adapted across institutions and countries. Its tools – indicators, surveys, and role-mapping matrices etc. – can be integrated into national VET monitoring systems to support data-driven policy and institutional decisions. Ultimately, this strategy empowers VET schools to act as both learners and leaders within regional and international knowledge networks, accelerating the systemic VocEx advancement.

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Marcello Jose Pio, Arman Yeltay, and Edgar Vieira Inacio

Anticipating the Future: The Strategic Value of Foresight Studies in TVET Development

This article examines the strategic value of foresight studies in shaping Technical and Vocational Education and Training (TVET) policy and practice. After reviewing core foresight techniques, it introduces SENAI's Industrial Foresight Model, detailing its stages: technological and organizational foresight, occupational impact analysis, and the Thematic Antenna for tailored recommendations. The model demonstrates how anticipatory intelligence can drive curriculum innovation, foster meaningful stakeholder collaboration, and strengthen institutional resilience. By aligning training pathways with labour-market dynamics and sustainability imperatives, this framework offers a replicable blueprint for TVET systems seeking to navigate rapid socio-technical change.

1 Introduction

As nations strive to improve their competitiveness and foster inclusive growth, the use of foresight studies has become an essential tool in designing strategic actions that align Technical and Vocational Education and Training (TVET) with future labour market needs, technological advancements, and societal transformations.[1] The article explores these studies' relevance of foresight studies for TVET and how the Brazilian National Service for Industrial Training (SENAI) applies them in its curriculum and policy management.

The article starts with a brief analysis of the importance of foresight studies in policy and management domains. In section two, the authors explore the main tools of these studies applied to TVET. The section three gives a practical example of how SENAI uses foresight studies in identifying the future demand for skilled labour in the industry. The last session closes with final consideration.

2 Foresight study as an essential tool in educational policy management

Foresight studies, also referred to as foresight analysis, involve systematically examining possible future developments to guide decision-making in the present. Authors such as Godet (2001) and Miles (Miles/Saritasa/Sokolov 2016) emphasize the value of foresight methodologies in structuring long-term policies that enhance the resilience and adaptability of educational and training systems.

1 We acknowledge the usage of AI for translation from Portuguese to English with Gemini and Copilot in April 2025.

From a labour market perspective, foresight studies help identify the skills, abilities, and knowledge in demand in the coming years. The rapid evolution of industries due to globalization, digital transformation, and sustainability imperatives requires a dynamic TVET system that can anticipate and respond to emerging trends. Schwab (2017) highlights that the Fourth Industrial Revolution reshapes economies by integrating artificial intelligence, robotics, and advanced manufacturing techniques.

Emerging economies often experience volatile labour markets influenced by external shocks, demographic changes, and shifting global supply chains. Through forecasting techniques, decision-makers can assess different economic trajectories and develop flexible TVET strategies that enhance employability and productivity. In this context, foresight approaches can bridge the gap between education and industry by fostering stronger partnerships and creating adaptive learning environments (Martin/Johnston 1999).

One critical aspect of social development is ensuring that TVET supports lifelong learning and continuous skill upgrading. With increasing automation and job displacement, workers need reskilling and upskilling opportunities to remain relevant in the labor market. The European Centre for the Development of Vocational Training (CEDEFOP) emphasises the importance of systemic reforms inspired by the Bruges communiqué 2010, focusing on learning-outcomes-oriented standards and curricula (CEDEFOP 2015). CEDEFOP also underscores the need to continuously improve TVET systems to enhance employability, social inclusion, and personal development.

Integrating new technologies into TVET is the area in which foresight studies prove indispensable. The digitization of education, including online learning platforms, virtual reality simulations, and artificial intelligence-driven training tools, is revolutionizing how vocational skills are acquired and assessed. According to UNESCO (2019), leveraging foresight methodologies can help TVET institutions anticipate technological disruptions and integrate cutting-edge solutions that enhance learning effectiveness.

Emerging technologies also necessitate the redefinition of traditional pedagogical methods. For instance, the concept of Industry 4.0 demands that TVET institutions incorporate smart technologies, automation, and data analytics into their training programmes. Foresight studies can guide the implementation of these innovations by identifying the best practices, assessing feasibility, and ensuring that technological advancements align with national development goals.

Innovation is a key driver of economic competitiveness, and foresight approaches can enhance the innovative capacity of TVET systems. By identifying future research and development trends, foresight studies support the creation of TVET programmes that foster creativity, entrepreneurship, and problem-solving skills. Schumpeter (2021) points out the role of innovation in economic development, and TVET institutions can become incubators of innovative talent if they are strategically aligned with emerging technological paradigms.

In the context of sustainable development, foresight studies contribute to aligning TVET with green skills and sustainable practices. As industries transition towards environmentally-friendly production methods, there is a growing need for vocational training programmes that equip workers with competencies in renewable energy, circular economy models, and eco-friendly construction techniques. Reports by the International Labour

Organization (ILO 2019) emphasize the role of green TVET in fostering sustainable economic growth.

The strategic application of foresight studies in TVET planning can drive economic development, social progress, technological modernization, and innovation-led growth in emerging countries. By anticipating future trends and proactively designing adaptive vocational training programmes, policymakers can ensure that TVET catalyzes sustainable and inclusive development.

3 Characteristics of foresight tools for TVET

To develop effective foresight studies in TVET, foresight tools and methods must exhibit key characteristics that ensure relevant, actionable, and strategic insights to guide educational policies and workforce development. Below are five essential characteristics of effective foresight tools and methodologies:

- **Future-Oriented and Systematic Approach** – Foresight tools must take a structured, long-term view of possible future developments in education and labor markets. They should systematically analyze trends, weak signals, and potential disruptions that could impact TVET. Methods such as scenario planning and horizon scanning allow researchers to explore multiple future possibilities, enabling policymakers and educators to prepare for a range of outcomes rather than reacting to immediate challenges. A future-oriented approach ensures that education systems remain adaptive and aligned with evolving skill requirements.
- **Stakeholder Inclusivity and Participatory Methods** – A well-rounded foresight study in education must integrate diverse perspectives from key stakeholders, including educators, students, policymakers, industry leaders, and civil society. Participatory methods such as the Delphi technique, focus groups, and expert panels provide a comprehensive understanding of future skill needs and learning environments. Engaging stakeholders in the foresight process enhances the accuracy of insights and increases the likelihood of acceptance and implementation in education policies and curriculum.
- **Flexibility and Adaptability to Emerging Trends** – Given the rapid pace of technological, economic, and social change, foresight tools must be flexible and capable of integrating new information as it emerges. Continuous monitoring and iterative updates to foresight studies help education systems stay relevant in a dynamic environment. For instance, real-time labour market data and advances in artificial intelligence refine predictions about future skills demand, allowing TVET and basic education programmes to adapt proactively rather than react retrospectively.
- **Policy and Action-Oriented Recommendations** – Beyond identifying possible futures, foresight studies should provide clear, actionable recommendations for decision-makers. This includes designing policy roadmaps, creating implementation frameworks, and proposing strategies for curriculum development, teacher training, and infrastructure investment. Insights generated must be communicated in a way that is accessible to edu-

cators and policymakers, ensuring that foresight translates into practical initiatives that improve educational outcomes and workforce readiness.

By integrating these characteristics, foresight tools and methods can meaningfully contribute to TVET's long-term strategic planning, helping societies prepare for future challenges and opportunities.

4 Industrial Foresight Model

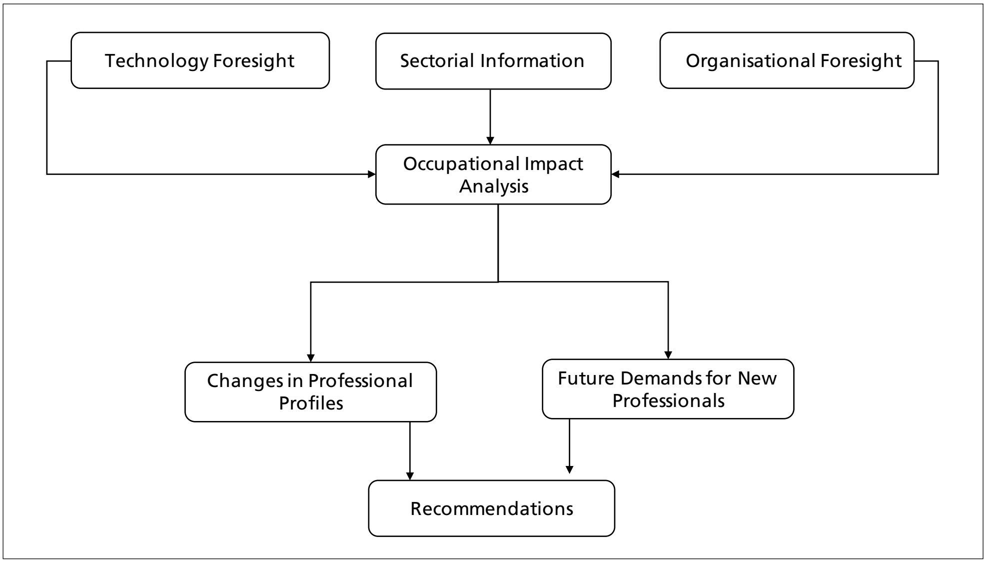
Basic concepts

To address challenges related to potential changes in occupational and educational profiles, SENAI applies the Industrial Foresight Model, which includes identifying the future demand for skilled labour in the industry as one of its key areas of focus. The results of the Model enhance the preparedness of professional training institutions in supplying specialized labour while also guiding companies in their hiring processes. This approach mitigates the negative effects of workforce shortages, particularly during phases of economic growth when demand intensifies. The Model considers the following dimensions:

- Impact of technological and organizational changes on industrial occupations.
- Identification of likely changes in occupational profiles.
- Anticipation of changes in the vocational education offerings, including regular training and requalification courses.

To identify future occupational shifts, the Model employs a set of interconnected foresight-driven methodological activities based on well-established foresight tools. Figure 1 illustrates the flow of activities within the Model's process aimed at identifying future professional training needs.

Figure 1: Overview of the Industrial Foresight Model



Source: Authors' elaboration

Description of the stages

Technological and Organizational Foresight

Technological foresight focuses on identifying Specific Emerging Technologies (SETs) – defined in the Model as innovations in early development stages, pre-commercialized solutions, or technologies recently introduced to the market but with limited adoption. Regardless of how long these technologies have existed, the Model estimates their market diffusion, a five to ten-year horizon.

Organizational foresight seeks to identify changes in the structural organization of industries or specific segments within the same a five-to-ten-year timeframe used for technological prospecting. It is based on the principle that, to better address the uncertainties and prepare organizations for future scenarios, each sector or production structure must understand how key influencers will shape its macro-management framework.

Occupational Impact Analysis

Following technological and organizational foresight, **Occupational Impact Analysis** identifies and evaluates, in collaboration with industry representatives and academic institutions, how **emerging technologies** and **organizational shifts** will influence professional profiles.

This understanding will allow the identification of a series of possible new activities and skills related to certain occupational groups. Changes in vocational education emerge as new **knowledge, skill, and abilities standards** are established – ultimately shaping new professional qualifications. In addition to adaptations within existing occupations, this phase also recognizes **new professional roles** that industrial companies will require within the next five to ten years, reflecting the diffusion of SETs and evolving organizational trends. These insights allow vocational training institutions to adjust their programmes to meet future workforce demands.

Recommendations (Thematic Antenna)

The Thematic Antenna represents the final stage of the Model's application. It consolidates all findings from the previous phases and analyses the results to formulate recommendations for decision-makers within the SENAI system. These recommendations guide future initiatives for Professional Training and Human Resource Development, ensuring institutions remain ahead of industry needs.

Additionally, vocational training institutions can act as agents of technological induction, facilitating the adoption of new technologies through activities that reduce uncertainty among industry stakeholders, particularly during the acquisition phase of SETs.

5 Final Considerations

When a TVET institution applies foresight tools or methodologies, several significant outcomes can be expected. These outcomes enhance its ability to anticipate challenges, align training programmes with labour market demands, and foster innovation. One of the primary results is the identification of future skill needs. By analyzing technological, economic, and societal trends, institutions can foresee which competencies will be crucial in the coming years. This ensures that curricula remain relevant, reducing the risk of skill mismatches and increasing the employability of graduates. Anticipating these changes allows TVET institutions to proactively develop training programmes that equip students with the expertise required in evolving industries.

Another key outcome is the strategic development and innovation of curricula. TVET institutions can redesign educational programmes incorporating emerging technologies and new pedagogical approaches. For instance, if studies predict a growing demand for green jobs, institutions can introduce specialized training in renewable energy, sustainable construction, or circular economy practices. Additionally, foresight-driven curriculum planning supports integration of flexible learning models, such as modular courses and digital platforms, ensuring that education remains accessible and adaptable to different learner needs.

Foresight tools also strengthen engagement with economic sectors and stakeholders. Anticipating future trends often involves collaboration with employers, policymakers, and labour market experts. These partnerships enable TVET institutions to develop work-based learning opportunities, apprenticeships, and research initiatives that align with industry needs. Engaging stakeholders in foresight exercises fosters a dynamic and responsive educational environment, ensuring training programmes continuously adapt to real-world demands. This collaboration guarantees that students gain hands-on experience and practical knowledge, translating directly into employment opportunities.

Another crucial benefit is enhanced resilience and adaptability of TVET institutions. Foresight helps institutions prepare for uncertainties such as economic fluctuations, technological disruptions, and demographic shifts by analyzing multiple future scenarios. Instead of reacting to changes as they occur, TVET institutions can develop contingency plans, diversify their programme offerings, and implement strategies that enhance long-term sustainability. This proactive approach allows institutions to remain relevant in a rapidly evolving world, meeting the needs of both students and employers.

Finally, applying foresight tools leads to better policy alignment and funding opportunities. Evidence-based insights generated through foresight studies can guide decision-makers in shaping national and regional education policies, ensuring that TVET institutions receive the adequate support to implement future-ready strategies. Institutions that align their programmes with long-term labour market projections and economic development goals are more likely to attract investments from governments, the private sector stakeholders, and international organizations.

To ensure the effectiveness of TVET foresight initiatives, interdisciplinary collaboration among governments, industry leaders, academic institutions, and civil society organizations is essential. The TVET institutions should highlight the importance of multi-stakeholder engagement in co-creating future-ready education and training policies. Such collaborations can enhance the robustness of foresight exercises and lead to more holistic and inclusive policy outcomes.

Despite its advantages, implementing foresight methodologies in TVET planning comes with challenges. Limited access to high-quality data, methodological uncertainties, and resistance to change can hinder the effectiveness of foresight studies. However, overcoming these barriers through capacity-building programmes and investment in research infrastructure can strengthen the role of foresight in shaping TVET systems.

The application of foresight methodologies equips TVET institutions to become more innovative, future-oriented, and resilient, ultimately reinforcing their role in workforce development and economic growth.

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Helmut Dornmayr, Lukas Graf, Stephan Kroll, Jörg Markowitsch, Daniel Neff, and Jörg Neumann

Comparing Dual VET Systems in Austria, Germany and Switzerland – Pilot Project to Identify Useful Indicators and Develop a Monitoring System

The value of internationally comparable data in vocational education and training (VET) is increasingly recognised, but there is a fundamental lack of comparative in-depth data on VET across countries – especially when it comes to dual VET even in neighbouring countries with similar dual VET systems. In a collaborative project between ibw and 3s in Austria, the Federal Institute for Vocational Education and Training (BIBB) in Germany, and the Swiss Federal Institute for Vocational Education and Training (SFUVET), a first step was taken to identify useful indicators and develop a monitoring system across the three countries. Selected findings are presented and briefly discussed. The chapter concludes with a discussion and reflection on possible next steps.

1 Introduction

Vocational education and training (VET) systems face complex challenges. Increasingly, VET stakeholders are realising that a sound data basis is needed to inform policymaking and analysis, a need that was further urged by the COVID-19 pandemic[1]. Comparative VET indicators thus function as early warning mechanisms and allow to track the performance of VET systems over time to evaluate if certain policies are achieving the desired outcomes, such as improved participation in the apprenticeship market. Evidence-based data analysis hence enables policymakers to develop targeted measures to address these challenges.

Moreover, the value of internationally comparable data in VET is increasingly recognised. Analysing cross-country differences can help identify the characteristics and measures of VET systems that lead to better qualification or labour market outcomes for graduates (Kɪs 2020). This helps policymakers to identify potential best practices and successful strategies in other countries, which could be adapted to their own context. Comparable data also foster international collaboration. By creating a shared understanding of VET systems and by identifying relevant comparable indicators, a common language

1 In Switzerland, for example, a task force was put in place to develop measures to cushion an expected shock, as the apprenticeship contract monitoring data showed a backlog of signed apprenticeship contracts of 3 to 4 per cent compared to the pre-pandemic period. URL: **https://dievolkswirtschaft.ch/de/2022/11/die-ausgebliebene-lehrstellenkrise-und-was-man-daraus-lernt/** (Retrieved on 15.04.2025).

emerges, which can be used for discussing and improving VET policies in a globalised economy, where workforce mobility and skill recognition across borders are crucial. A number of international organisations such as the OECD with VET PISA[2], Cedefop with the European VET policy dashboard[3], UNESCO-UNEVOC's TVET country profiles[4] or the BIBB's apprenticeship toolbox[5] are already engaged in building up comparative databases. Their common aim is to inform policy or work on internationally agreed definitions, for example, the definition of quality apprenticeship by the ILO 2023[6].

Despite these positive developments, there is a fundamental lack of comparative in-depth data on VET across countries, especially when it comes to *dual* VET[7]. This is partly due to differing underlying concepts, definitions, classifications and measurement methods. In this context, even a comparison between neighbouring countries with similar dual VET systems is often dependent on ad hoc analyses and individual projects. Thus, the aim of this contribution is to describe our efforts to identify useful indicators and develop a monitoring system that compares dual VET systems in Austria, Germany and Switzerland. First, we give an overview on some of the major VET data reporting projects in the three countries. Next, we present selected insights from our pilot project, with a focus on comparing relevant data. We conclude with a discussion and reflections on possible next steps in the field of comparative data reporting for dual VET systems.

2 VET data reporting in Austria, Germany and Switzerland

Austria, Germany and Switzerland each have substantial data-driven monitoring systems in place to inform VET policy.

In Austria, the ibw (ibw Austria – Research & Development in VET) publishes an annual overview about the general situation of dual VET (Dornmayr 2024). It pursues the objective of presenting all relevant and available statistical data and indicators on apprenticeship training. The publication is (financially) supported by the Federal Ministry of Labour and Economy as well as the Austrian Economic Chambers. The latter, as the responsible authority, generates and provides statistical data concerning apprenticeship training. Every two years the Federal Ministry of Labour and Economy provides the "Report on Youth Employment and Apprenticeship Training in Austria" (conducted by ibw and the Austrian Institute for Research on Vocational Education and Training (öibf); Dornmayr/Löffler 2024).

2 URL: **https://www.oecd.org/en/publications/pisa-vocational-education-and-training-vet_b0d5aaf9-en.html** (Retrieved on 15.04.2025).

3 URL: **https://www.cedefop.europa.eu/en/data-datasets/european-vet-policy-dashboard** (Retrieved on 15.04.2025).

4 URL: **https://unevoc.unesco.org/wysd/TVET+Country+Profiles** (Retrieved on 15.04.2025).

5 URL: **https://www.bibb.de/en/apprenticeshiptoolbox.php** (Retrieved on 15.04.2025).

6 URL: **https://normlex.ilo.org/dyn/nrmlx_en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:R208** (Retrieved on 15.04.2025).

7 Data collection in dual VET systems can be especially complex – not least due to the different locations of learning (vocational school, company, and partly inter-company courses).

In Germany, the Federal Ministry of Education and Research (BMBF) has the duty to monitor the developments in VET, according to the Vocational Training Act in Germany. The ministry thus, supported by the Federal Institute of Vocational Education and Training (BIBB), publishes a political VET report on a yearly basis, which is supplemented by a non-political Data Report on the VET report published by the BIBB, providing extensive information and analysis of VET in Germany (see BIBB 2025)[8]. The BIBB Data Report contains differentiated presentations of key indicators of VET, and includes time series and projections, encompasses a yearly changing thematic priority on different topics in training and further education. As such the BIBB Data Report has manifested itself as an indispensable tool for policy which serves as the foundation for VET policy.

In Switzerland, the situation of the entire education system is monitored by the Swiss Coordination Centre on Education Research, which publishes its results every four to five years in form of a general report. The situation of VET in particular is monitored by the Swiss Observatory for Vocational Education and Training (OBS SFUVET). Its monitoring started in 2016 and consists of a monitoring of relevant literature as well as parliamentary proceedings related to VET. This includes national and international scientific and non-scientific literature. Furthermore, all federal and cantonal written parliamentary businesses (e.g. motions, postulates) related to education and mainly VET are taken into account. These sources are coded according to a systematic framework model. On this basis, the OBS diagnoses through quantitative and qualitative assessments if certain trends correspond with distinct system inputs and outcomes. Prominent trend topics are then investigated in-depth. The results are displayed on the interactive website and in the form of “Trend Reports”, “Trends in Focus” policy briefs, and scientific or media articles.

While Austria, Germany and Switzerland closely monitor the development of their system, there is a lack of comparable and detailed data on dual VET between these neighbouring countries. This is also due to the differing concepts, definitions, classifications, and measurement methods. Nevertheless, it can be observed that the national focus is increasingly being complemented by an international one.

The annual overview on dual VET (“Lehrlingsausbildung im Überblick”) by the ibw contains a chapter entitled “Austria in European comparison (EU-27-countries)”, which is based on Eurostat and OECD data. Furthermore, the reporting contains some selective and specific comparisons to Germany (BIBB Data Report). The first BIBB Data Report for Germany in 2009 already included a chapter on “European and international co-operation in vocational education and training” and in recent years also compared selected countries on specific indicators. The OBS trend report on areas of tension in VET in Switzerland and other countries (Kriesi et al. 2022) investigated current developments, challenges and potentials. It dedicated two chapters on comparisons of Swiss and European VET systems. Moreover, individual projects have attempted to implement in-depth comparisons between the countries (see e.g. DC DVET 2016; Ebner/Nikolai 2010; Graf 2016; Lassnigg 2023; Schlögl/Mayerl 2017). All in all, this shows that such data-driven international compar-

8 URL: **https://www.bibb.de/datenreport/en/13621.php** (Retrieved on 15.04.2025).

isons become more important but are still slowed down by the limited availability of comparative data on dual VET.

3 Developing a comparative monitoring system – first insights from a pilot project

Hereafter, we present selected results from our pilot project[9], which explores the option to establish a regular monitoring of the development of dual VET in the D-A-CH region based on specific indicators (Dornmayr et al. 2025). Such a monitoring would strengthen the existing informal exchange between the countries, would serve as a model for the European Alliance for Apprenticeships (EAfA) and could even contribute to a more systematic securing of skilled labour in the long term. If the underlying structures and framework conditions are known and correctly understood, reciprocal impulses and suggestions from the different education systems and programmes can be classified and absorbed. This could contribute to the further development and professionalisation of VET in the D-A-CH region.

Austria, for example, could gain insights regarding the development of higher VET, starting from a situation that differs in many respects from the situation in Germany and Switzerland – for instance, in terms of the importance of dual VET at secondary level or the proportion of high school graduates among new apprentices. In Germany, the VET discourse is still strongly characterised by an internal perspective. A comparison could help to open up and enrich the discussion by providing an external perspective. In particular, a focus on the different developments in other dual VET systems and the associated steering mechanisms would be of interest. For Switzerland, the comparison can be instructive, for example, in the sense that some of the demographic or education system developments prominent in partner countries, like the ongoing academisation, have not yet materialised in the same way (Kriesi et al. 2022) but could soon become more salient.

To illustrate, we next present selected indicators that have been developed and used in our pilot project.

3.1 Demographic trends and number of apprentices (2003–2023)

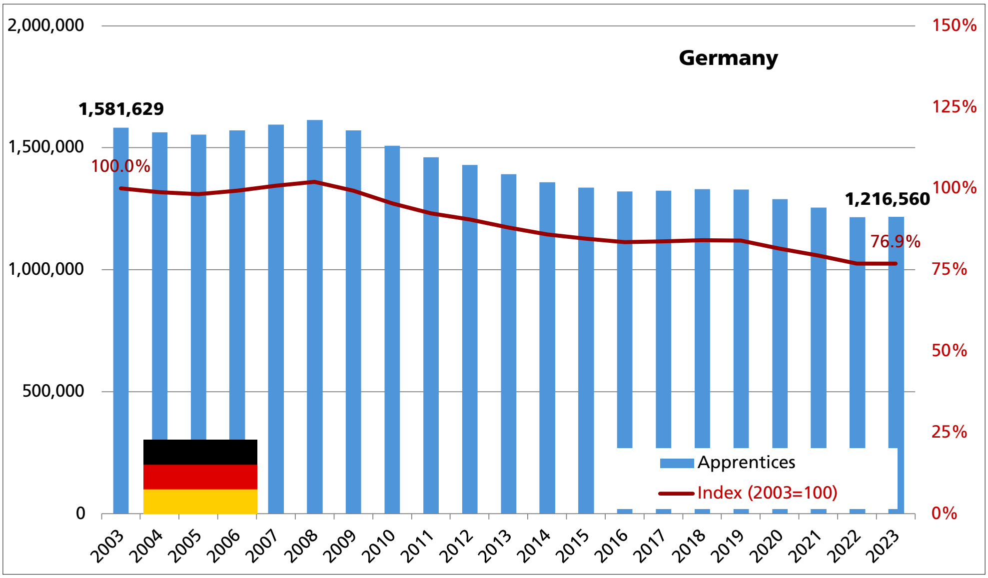
Compared to the base year 2003, the number of apprentices in Germany has continuously decreased, which was only briefly halted by the increased immigration due to the refugee movement starting in 2015. Since 2019, the number of apprentices has significantly declined again, despite the rising number of 15-year-olds. However, since the average age for new apprentices in Germany is quite high at 20 years, the upswing of 15-year-olds will impact the number of trainees only in the coming years. This is due to delayed entries into dual VET, mainly for two reasons: While academically strong 15-year-olds often continue

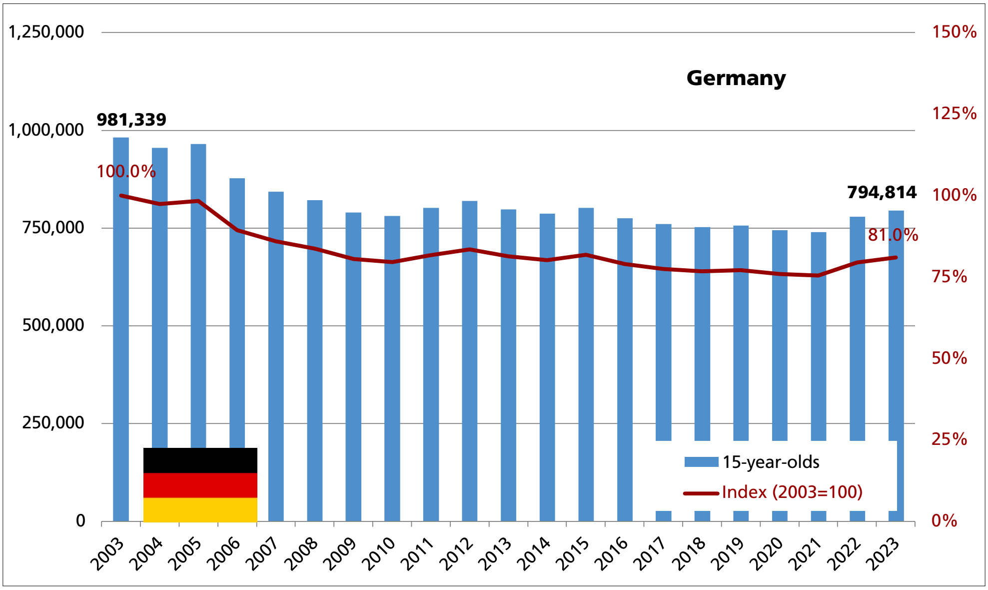
9 The project is the result of collaboration between ibw and 3s in Austria, the Federal Institute for Vocational Education and Training (BIBB) in Germany, and the Swiss Federal Institute for Vocational Education and Training (SFUVET).

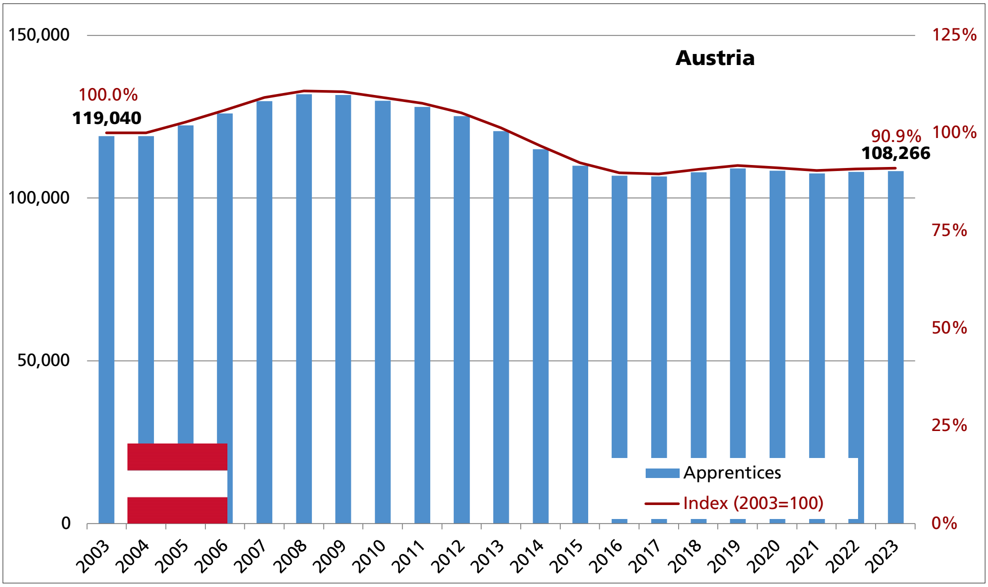
general education and acquire a university entrance qualification before entering dual VET, academically weaker 15-year-olds often participate in pre-vocational training programmes.

In Austria, the number of apprentices (and 15-year-olds) fell sharply from 2010 to 2015 in particular but has remained stable since then. In Switzerland, no nationwide decline in the number of apprentices at upper secondary level can be observed. In the period under review (2003 to 2023), it is even possible to observe a slight growth overall (see Figure 3.1-1).

Figure 3.1-1: Total number of apprentices and 15-year-olds in the D-A-CH region (2003–2023)



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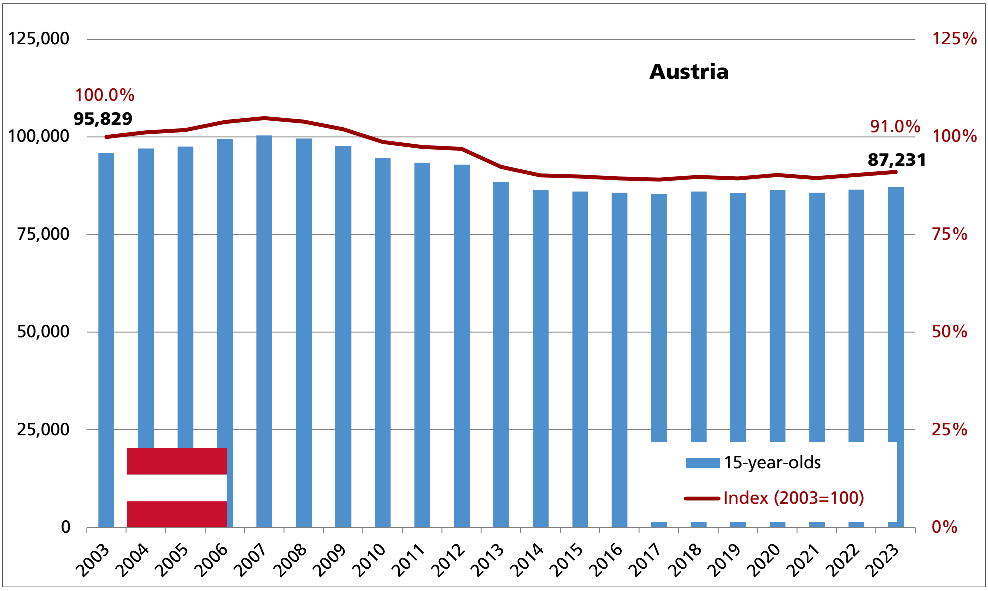
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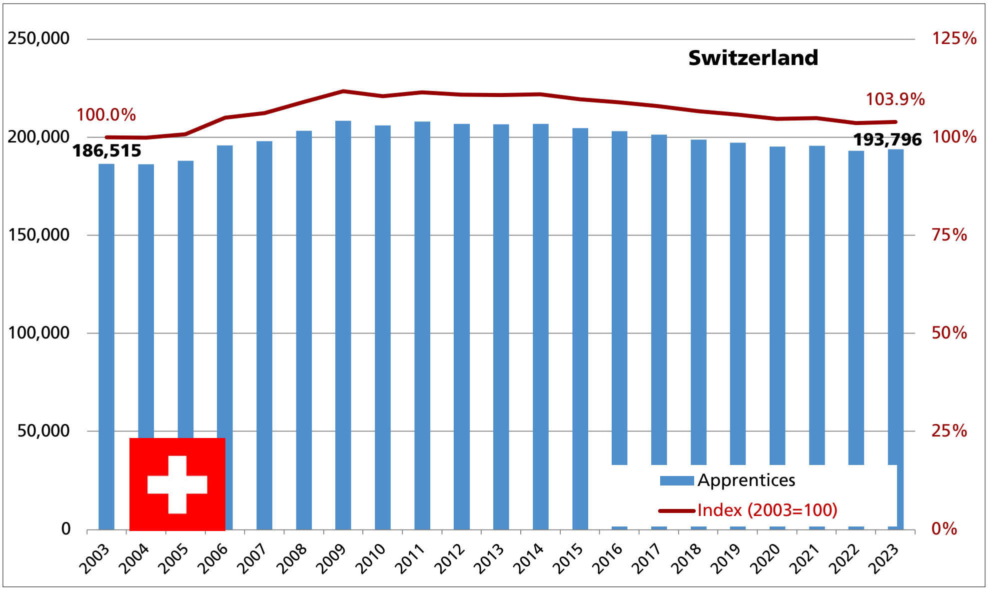
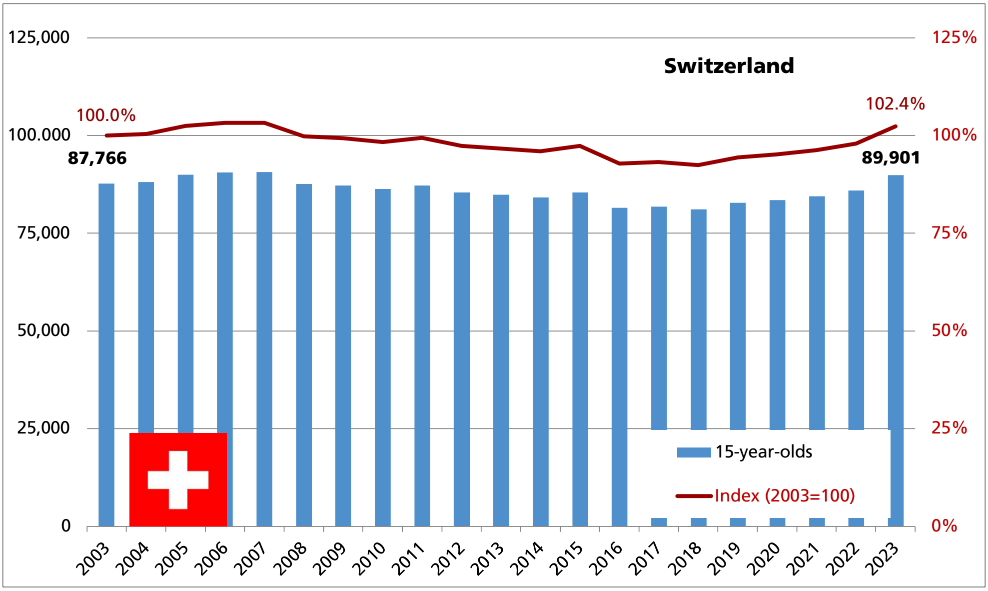




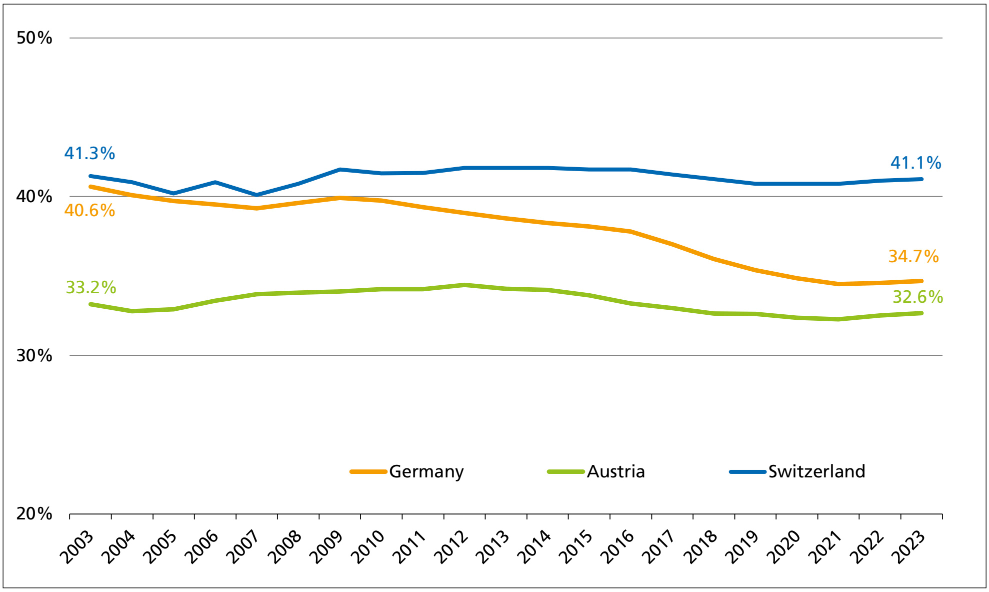
Source: Germany: Number of apprentices and trainees: "Data System for Trainees" (DAZUBI) of the Federal Institute for Vocational Education and Training (BIBB) based on the data from the vocational training statistics of the statistical offices of the federal and state governments (survey as of December 31); population statistics: Federal Statistical Office (Destatis) based on the 2021 census. Austria: WKO (number of apprentices and new apprentices as of December 31) + Statistics Austria (number of 15-year-olds on average per year) + ibw calculations. Switzerland: Statistics of learners (number of apprentices; as of July 31); statistics of the annual population count ESPOP and statistics of the population & households STATPOP (number of 15–20-year-olds; as of December 31); statistics of VET (number of new apprentices; as of July 31)

3.2 Proportion of female apprentices (2003–2023)

In order to better understand these developments, a further breakdown by gender is needed, as the overall number of apprentices is also driven by different developments according to gender. The proportion of female apprentices must be seen in the context of the existing training programmes in the D-A-CH countries. The integration of healthcare and social professions into the dual VET system is particularly significant in Switzerland (Healthcare Assistant, Federal Diploma of Vocational Education and Training [FDV] as well as Certified Social Care Worker, FDV), which is only just beginning in Austria (introduction of the nursing apprenticeship as a trial in 2023). In Germany, only a minority of healthcare occupations is provided through the dual system (e.g. medical assistants). The majority of healthcare, education, and social service occupations (GES occupations), however, is offered as school-based VET programmes. Apprentices in school-based VET programmes – which have traditionally been attended predominantly by women – are therefore not included in the training statistics for the dual system. This must be considered when interpreting the proportion of women in the dual system in Germany.

In Germany, since the late 2000s, the number of students has declined significantly due to previously low birth rates. As a result, fewer young people were potentially available to the training market. This decline could be at least partially offset by the influx of predominantly male migrants and their integration into dual VET. However, this compensatory effect did not occur for women, or only to a limited extent, which at least somewhat explains the decline in the proportion of women in the dual VET system (see Figures 3.1-2 and 3.1-3).

Figure 3.1-2: Proportion of female apprentices in the D-A-CH region (2003–2023)



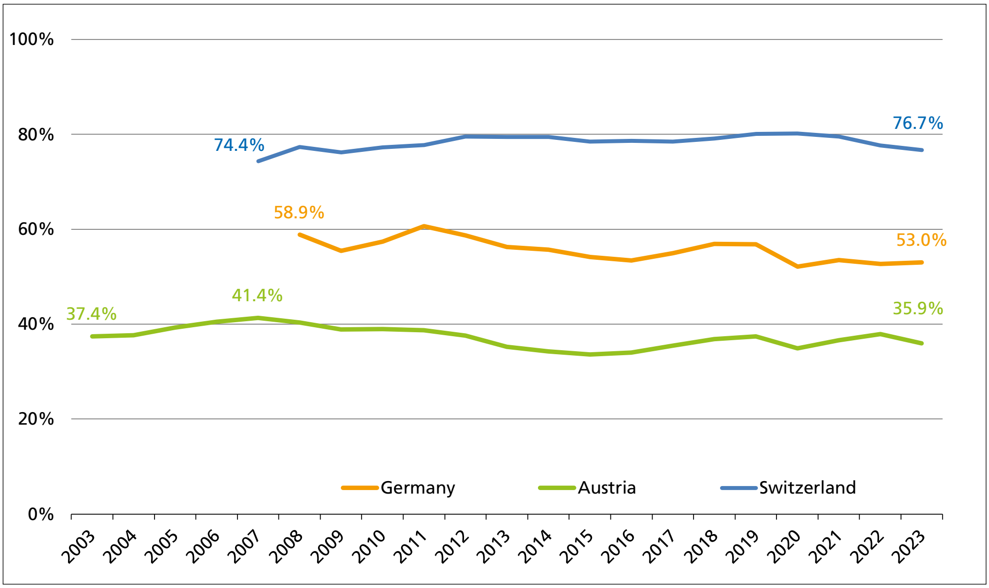
Note: The figures for Germany refer to the vocational training beginners.

Source: Germany: Number of apprentices and trainees: "Data System for Trainees" (DAZUBI) of the Federal Institute for Vocational Education and Training (BIBB) based on the data from the vocational training statistics of the statistical offices of the federal and state governments (survey as of December 31); population statistics: Federal Statistical Office (Destatis) based on the 2021 census.
Austria: WKO (number of apprentices and new apprentices as of December 31) + Statistics Austria (number of 15-year-olds on average per year) + ibw calculations.
Switzerland: Statistics of learners (number of apprentices; as of July 31); statistics of the annual population count ESPOP and statistics of the population & households STATPOP (number of 15–20-year-olds; as of December 31); statistics of VET (number of new apprentices; as of July 31).

As has been shown, the number of apprentices in the D-A-CH countries is influenced mostly by demographic trends (number of 15-year-olds) and the position of dual VET in the overall education system. By calculating a proxy apprenticeship starter rate,[10] one can estimate that around 36 percent of young people in Austria start an apprenticeship (in the course of their lives); this figure is currently around 53 percent in Germany and around three quarters in Switzerland (see Figure 3.1-3). For a comparison of the most chosen occupations by gender, see Dornmayr et al. (2025).

10 The apprenticeship starter rate is the proportion of apprenticeship starters of a fictitious birth cohort which is calculated as one sixth of the age cohort of the 15–20-year-olds.

Figure 3.1-3: Proportion of apprenticeship starters in a fictitious birth cohort (2003–2023)



Note: In Austria, the number of 'apprentices in the first year' is usually used to calculate this indicator instead of the number of 'beginning apprentices'.

Source: Germany: Number of apprentices and trainees: "Data System for Trainees" (DAZUBI) of the Federal Institute for Vocational Education and Training (BIBB) based on the data from the vocational training statistics of the statistical offices of the federal and state governments (survey as of December 31); population statistics: Federal Statistical Office (Destatis) based on the 2021 census.
Austria: WKO (number of apprentices and new apprentices as of December 31) + Statistics Austria (number of 15-year-olds on average per year) + ibw calculations.
Switzerland: Statistics of learners (number of apprentices; as of July 31); statistics of the annual population count ESPOP and statistics of the population & households STATPOP (number of 15–20-year-olds; as of December 31); statistics of VET (number of new apprentices; as of July 31).

4 Suggestions for a future comparative VET monitoring

So far, our work on this pilot project for the development of relevant indicators to comparatively describe the dual VET systems in Germany, Austria and Switzerland has highlighted two aspects: First, due to the different systems, classifications and definitions, it is complicated (and time-consuming) to generate a comparable database and thus a common understanding of the VET systems, which are quite different when zooming in on details. This implies that sufficient resources are needed if one wishes to institutionalise such a monitoring in the long run. Second, the country comparison on the basis of selected indicators is highly relevant in terms of content and also enlightening and beneficial for all parties involved. When developed further – both in terms of the number of indicators and the time period covered – such a monitoring is able to provide important impulses and starting points for the evaluation and optimisation of the educational systems and training programmes in Austria, Germany and Switzerland but also other countries with dual VET systems.

In the future, the project could extend the analysis and include tertiary level education, i.e. professional education, which has a long tradition in Germany and Switzerland, but was only just launched in Austria.

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Ingrid Pamela Zúñiga-López and Roberto Díaz-Páez

Data Reporting and Monitoring in Dual Vocational Education and Training (VET) in Costa Rica: An Analysis of the Institutional Trajectory and Ecosystem for Evidence-Based Decision Making in the Period 2022 to 2024

From 2022 to 2024, data reporting and monitoring at the Costa Rican National Institute of Apprenticeship (INA) played a fundamental role in ensuring quality improvements to vocational training systems. The process of developing a model that promotes effectiveness, accountability and alignment with the needs of the productive ecosystem has revealed structural and circumstantial challenges. These aspects reveal important lessons for the institutionalisation of evidence in decision-making processes, including the role, benefits and current challenges of monitoring and reporting in VET due to regional differences and data management challenges. This article explores the institutional ecosystem for the implementation of an evidence-based decision-making policy in VET. Moreover, it sets out the key elements required to reinforce and construct a culture of data-driven public policy.

1 Introduction

Tracking and evaluating the training programs effectiveness in VET systems are essential tools provided from data reporting and monitoring.[1] The stakeholders, as educational institutions, policymakers, industry partners and learners, can get information to assess the vocational training success and identify improvement areas (see Grollman et al. 2021). The collection, analysis, and reporting of data could ensure that vocational training systems provide relevant skills that meet the demands of the labour market, strengthening continuous improvement in the outcomes of the teaching-learning processes (see Meyer/Zierke 2024, p. 58).

In that sense, Costa Rica's recent history has been characterized by an unprecedented impetus towards evaluation, monitoring, and follow-up as essential functions in the implementation of public policies. Accountability, transparency, and evidence-based decision-making are understood as social demands that legitimize the public function and,

1 Usage of Deepl for translation of words and phrases, translation verification and concordance of the English text (June 2025) and usage of ChatGPT-4-turbo (20.02.2025) for outline of the document.

consequently, have an impact on the improvement of services, the strengthening of democracy and social coexistence.

This ecosystem generates a conducive space to a coherent narrative between any public policy, results, data management and evidence-based decision making. Although the INA has a long history about the dual training implementation, Law 9728[2] passed in 2019 set a fundamental precedent in the formalization of instruments that provided legal certainty to all actors involved, thus marking the need to have the tools and models to formalize mechanisms to monitor the results (see Asamblea Legislativa 2019).

This article presents the strategic and regulatory context of technical education and training of dual-mode and its purpose is to present the main arguments and summarize the key findings from experience obtained between 2022 and 2024.

2 Context of implementation of Law No. 9728

The Law 9728 Article 12.g) – Functions and Powers of the Advisory Commission indicated the duty to submit an annual report on the status of dual VET, which should be received and analysed by the Board of Directors of the National Institute of Apprenticeship (INA), the Ministry of Education (MEP) and the Board of Directors of the Costa Rican Union of Chambers and Associations of the Private Business Sector (UCCAEP), who may submit their substantive observations to the Commission.

3 Data Reporting and Monitoring Context

Law No. 9728 establishes the use of data as a body, however, in Costa Rica, there is a broader institutional landscape. In this sense, both the National Evaluation Policy and the instrumentalization of evaluation at the institutional level provide a first analysis level to the path towards the construction of an evaluation, monitoring, and follow-up system (see MIDEPLAN 2018).

At this point, it is essential to differentiate between these concepts, which in practical terms have different instrumental and methodological effects.

To make this analysis meaningful, the key aspects that make up an evaluation ecosystem are also taken as a reference framework, based on the National Evaluation Capacity Index initiative (INCE by its Spanish acronym), a collaborative diagnostic tool that measures evaluation capacities and practices at the national level, promoted by the German Institute for Development Evaluation (DEval) and the UN World Food Programme (WFP), and conceptually adopted by actors of national evaluation systems in Latin America.

2 Access the full version of the current law. ULR: **http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=89820&nValor3=118020&strTipM=TC** (Retrieved on 12.08.2025).

4 Experience in the development of a monitoring and evaluation system: learning along the way

As stated above, the dual vocational technical training implementation in INA since the entry into force of Law No. 9728 has been characterized by a process of learning and maturation, whose visible face has been evidenced in at least three aspects: 1) agreements with companies and students, 2) the execution of the allocated budget and 3) the number of graduates. In other words, and based on the conceptual framework presented, efforts have been focused on the monitoring and follow-up of primary management indicators, the follow-up of which is fundamental due to the various accountability processes.

From an institutional perspective, these results have been incorporated into various institutional tools, including the 2019–2025 Institutional Strategic Plan, the Dual indicators contained in the Annual Institutional Operational Plan and the 2023–2026 Institutional Dual Training Strategy. The latter builds on the experiences of the past two years and improves all reports to enable faster decision-making. Within the supra-institutional framework, the CAP generates annual accountability reports, which are approved by the institutional boards of directors for incorporation into daily activities.

In summary, the data collected in VET:

- Student data: enrolment figures, demographic information (age, gender, others), retention and graduation rates and learner engagement.
- Formation program data: course offerings information, educational and formation completion rates, student satisfaction, and overall program effectiveness.
- Performance data: assessment results, grades, competency completion rates, and feedback on students' practical skills development.
- Post-training outcomes: employment rates, uptake of further study, and feedback from Costa Rican employers on the graduates' skills. This is currently under review and will undergo quality improvement in the coming months.
- Feedback data: employers and students surveys, and other feedback mechanisms that assess the relevance and quality of training provided.

On the other hand, the experience of INA has been accompanied by a series of collaborative efforts to provide a reading that accompanies the need to move forward in the dynamic of efforts of the implementation strategy. In recent years, organizations such as UNICEF (see UNICEF-PEDAL 2023), OEI (see Quesada 2024) and ILO/CINTERFOR (see Axmann 2018) have conducted research, studies and publications that allow INA staff to understand their status and propose substantial improvements in strategic, administrative, and operational aspects. Likewise, the CICR and the INA updated their operating protocol to build on the experience gained from Dual Training with major industrial companies, which includes the evaluation and adjustment of the developed processes.

All monitoring and tracking for decision-making have allowed us to go from one enterprise agreement in 2022 to 110 in April of this year, and to have today, as per May 2025, 449 graduates from zero in 2022. There is also a methodological strategy for tracking graduates through COV-CAINA.

5 Benefits of Effective Data Reporting and Monitoring

Three of the most relevant benefits of effective data reporting and monitoring up to now are:

- Improved learning outcomes: precise reporting helps trainers and educators to improve their practices, ensuring better outcomes for learners. With those insights, teachers can adapt instructional methods and provide additional resources to the students.
- Enhanced industry collaboration: data reporting and monitoring allow training providers to demonstrate how well they are aligning with industry standards, which increases trust and collaboration with the business sectors. This facilitates more effective alternating space and better future job opportunities for students.
- Policy and funding impact: Well-documented reports can have a positive influence when it comes to policy formulation and attracting partners for specific areas that need development. Policymakers often rely on data to allocate resources, ensuring that vocational training systems meet national skill requirements.

The role of monitoring in VET is often related to the ongoing tracking of progress; monitoring involves the ongoing collection and analysis of data to track students' progress throughout their training. This allows for early interventions if students are struggling to achieve their desired outcomes that might include graduation rates, student employment rates after graduation, industry partnerships, and student satisfaction levels.

Finally, by continuously monitoring data, VET institutions can make timely adjustments to teaching methods, course content, and delivery models to enhance the learning experience. Monitoring allows for the perception of some emerging trends in the industries so that training programs remain relevant.

6 Challenges in Data Reporting and Monitoring

Reporting systems can be undermined by errors in data entry, inconsistencies in reporting standards, and a lack of reliable data sources. Due the enormous amounts of personal data that INA collects, safeguarding the privacy of students and training providers is crucial adhering to legal frameworks and the maintenance of robust data protection protocols are essential.

Also, VET providers operate in different regions, so data systems may not be always perfectly integrated. This can hinder the sharing of information and the generation of unified reports, affecting the ability to monitor training programmes effectively.

7 Beyond graduates: the transition to the employment world

As has already been shown, the institutional efforts have been focused on keeping up with quantitative data on the graduates' numbers, signed contracts and budget execution. While these efforts are in line with the maturity of the implementation process, it is necessary to move towards a culture of evaluation in its broadest sense.

In order to strengthen this approach, a strategic and orderly approach is required at different organisational levels. Both the INA and the institutions directly involved have demonstrated a commitment that transcends the political difficulties of the Costa Rican democratic system. On the other hand, as a necessary condition, the organizational culture towards evaluation and the reading of results for decision-making must be strengthened. The institutional trajectory has shown a gradual implementation of monitoring and follow-up as relevant aspects for decision making; however, for this and other initiatives, the implementation of actions with the clear intention of strengthening this component requires appropriation, procedures, and a clear methodology.

Along the same lines, strengthening the implementation model is an essential factor, so that capacities are generated in parallel to enable an evaluative ecosystem oriented to evidence-based decision making.

8 Conclusion

INA recognises data reporting as a vital component of its dual VET strategy. The most significant benefits are as follow:

- Data reports help both educational institutions and policymakers make informed decisions regarding curriculum development, resource allocation, and strategic planning. Through data, trends in student performance, course success rates, and employment outcomes the Institution can identified and acted to reduce gaps.
- Continuous monitoring of training quality is based on regular data reports. It helps ensure that training programs meet industry standards, are aligned with national qualification frameworks, and comply with accreditation requirements.
- Data reporting promotes accountability in training provider entities. Stakeholders can track investment, student enrolment figures, completion rates, and employment statistics to ensure that educational institutions are effectively using public funds.
- The data helps identify areas where training programs may be underperforming or where students face structural challenges. This information can guide adjustments in the curriculum or the introduction of additional support mechanisms.

Fundamental pieces for vocational training systems success are reporting and monitoring of data, ensuring that training programs respond to both the needs of students and the demands of the industry. With complete, precise, and timely data, interested parties can make informed decisions aimed at improving the education and formation quality, promoting transparency, and driving continuous upgrades. As vocational training evolves, adopting technological tools for data collection and analysis will further enhance the effectiveness of reporting and monitoring processes, consolidating a stronger ecosystem that ensures best practices in Costa Rica.

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Miriam Hänni, Belinda Aeschlimann, and Lukas Graf

OBS SFUVET Trend Monitoring – Identifying Trends in VET and Anticipating VET System Challenges

To support the governance of the VET system, the Swiss Observatory for Vocational Education and Training has been monitoring since 2018 how current megatrends – such as the digital, economic, and ecological transformations or upskilling and lifelong learning – affect key aspects of VET. We focus on which megatrends and developments have affected (Swiss) VET over the past years, how key aspects of the VET system are changing due to these developments, and where action is needed to ensure that the VET system remains functional and sustainable in a changing world. We have developed our own monitoring methodology, which includes a coding system to systematically analyse a source pool of documents, policy proposals and articles published by researchers, practitioners, and policymakers in Switzerland and beyond. This article provides an overview of our monitoring strategy and illustrative findings from our trend monitoring.

1 Introduction

Vocational education and training (VET) is embedded in a country's socio-economic and political system and is therefore challenged by various developments in its environment.[1] One of the central functions of VET is to systematically identify and respond to these multifaceted transformations to ensure that future skilled workers continue to be equipped with the competencies required by the labour market. VET practitioners, policymakers, and experts, therefore, are in need of monitoring activities that identify current and emerging social, technological, environmental, political, and economic trends and examine how they affect key aspects of the VET system, such as the required competencies of VET graduates or occupational aspirations of young people.

In light of this demand, the Swiss Observatory for Vocational Education and Training (OBS SFUVET) has developed a systematic monitoring process. Our search for important trends is thus not carried out by "gazing into a crystal ball" but through systematic research and analysis of a source pool of documents, policy proposals and articles published by researchers, practitioners, and policymakers in Switzerland and beyond (see below) (Trede/Aeschlimann 2019).

In this context, the following overarching questions motivate and guide our research:

1 We acknowledge the use of the AI tools DeepL (as of February 2025) and ChatGPT (model: GPT-4o, as of February 2025) to assist with proofreading. The AI tools were used exclusively for linguistic review (grammar, style and readability).

- What changes do recent social, technological, environmental, political, and economic developments bring to the VET system?
- What consequences do these changes have for individuals, society, the economy and the VET system?

As an observatory, transferring our knowledge into practice and to stakeholders within the VET system is an integral part of our work. Accordingly, we also address the following question:

- Where is action needed to ensure that the VET system remains functional and sustainable in the long run?

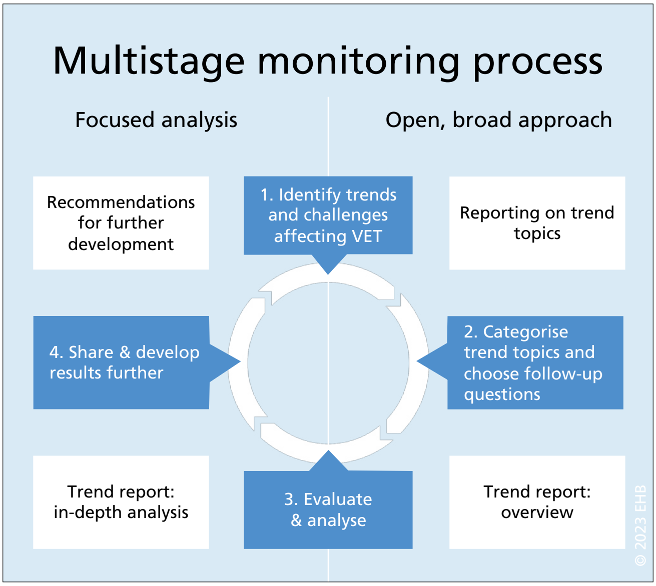
We address these questions through two interconnected monitoring activities, namely, a *literature monitoring* and a *political monitoring*. In the following, we first provide an overview of our monitoring strategy. We then highlight illustrative findings from the monitoring periods 2021 to 2024. The discussion reflects on our trend monitoring strategy from multiple perspectives and situates it within both national and international contexts.

2 Monitoring strategy

2.1 Monitoring process

To systematically address the key questions presented above, OBS SFUVET has established a structured, multistage monitoring process (see Figure 1). The process is not necessarily carried out in chronological order. While the stages may follow sequentially, they may also be skipped or carried out simultaneously, depending on the specific context and needs.

Figure 1: Multistage monitoring process



Source: own illustration of monitoring process

1. In a first stage, OBS SFUVET researchers[2] systematically screen the sources to **identify trends and challenges affecting VET**. Over the monitoring period of one year, they search and analyse recent publications from the source pool (see below) to identify developments and possible challenges affecting key aspects of VET. The quantitative and qualitative results of this trend monitoring are reported on the SFUVET website[3]. In addition, selected topics are explored in more detail in short policy papers (entitled 'Trend in Focus'), such as the Trend in Focus on *Innovative Teaching Methods* (Aeschlimann/Trede 2018) or on *VET in Politics: Parliamentary Perspectives on Current Challenges* (Hänni/Aeschlimann/Graf 2024).
2. In a second stage, we focus on **categorising trend topics and challenges and derive follow-up questions for further analyses**. For this purpose, researchers systematically work on a carefully selected trend topic and clarify its relevance for VET. This is done through an in-depth review of the source pool and the processing of statistical data. The results appear in the form of Trend Reports in the corresponding OBS SFUVET publication series, such as the Trend Report on *Digitalisation and VET* (Schweri et al. 2018) or on *Areas of Tension in Vocational Education and Training in Switzerland and Other Countries* (Kriesi et al. 2022).

2 The development and coding of the trend monitoring is a collaborative effort to which all staff members at OBS SFUVET contribute. See also URL: **https://www.sfuvet.swiss/research/obs/about-us** (Retrieved on 12.08.2025).

3 See URL: **https://www.sfuvet.swiss/research/obs/trend-monitoring-trends-in-VET** (Retrieved on 12.08.2025).

3. In a third stage, which can occur sequentially, in parallel or as an alternative to stage 2, we **evaluate and analyse specific trend topics in (even) greater depth**. This is done within specific research and development projects conducted by OBS SFUVET. The results are also published as Trend Reports or in scientific articles, such as the article *Successful Distance Teaching from the Perspective of Teachers at Swiss Colleges of Higher Vocational Education* (Hänni/Aeschlimann 2021) or the Trend Report *Qualification procedures put to the test* (Graf et al. 2024).
4. In a fourth stage, we **share the monitoring results** with representatives from the federal administration, the cantons, and professional organisations as well as with VET specialists who are members of the OBS SFUVET's Advisory Board **to further develop** our monitoring strategy and discuss our findings. In addition, we disseminate our monitoring results to the wider public, for example, through conferences and other transfer activities (e.g. newspaper articles).

Source Pool for the OBS trend monitoring

The data basis for the trend monitoring is a source pool comprised of articles from around 30 national and international journals and periodicals covering various disciplines and VET-related fields of activity. The source pool includes peer-reviewed journals as well as research reports, discussion papers, and policy papers (*literature monitoring*). In addition, the source pool provides access to information on policy issues related to VET by coding policy proposals and parliamentary questions submitted to cantonal parliaments and the Swiss Federal Assembly (*political monitoring*).

Since 2018, we have analysed over 3,000 articles and reports on VET practice, policies and research. In the same period, 15 'Trend in Focus' papers and 6 Trend Reports were published. In the most recent 2024 monitoring period (running from autumn 2023 to autumn 2024), researchers consulted around 760 research publications and examined around 50 policy issues.

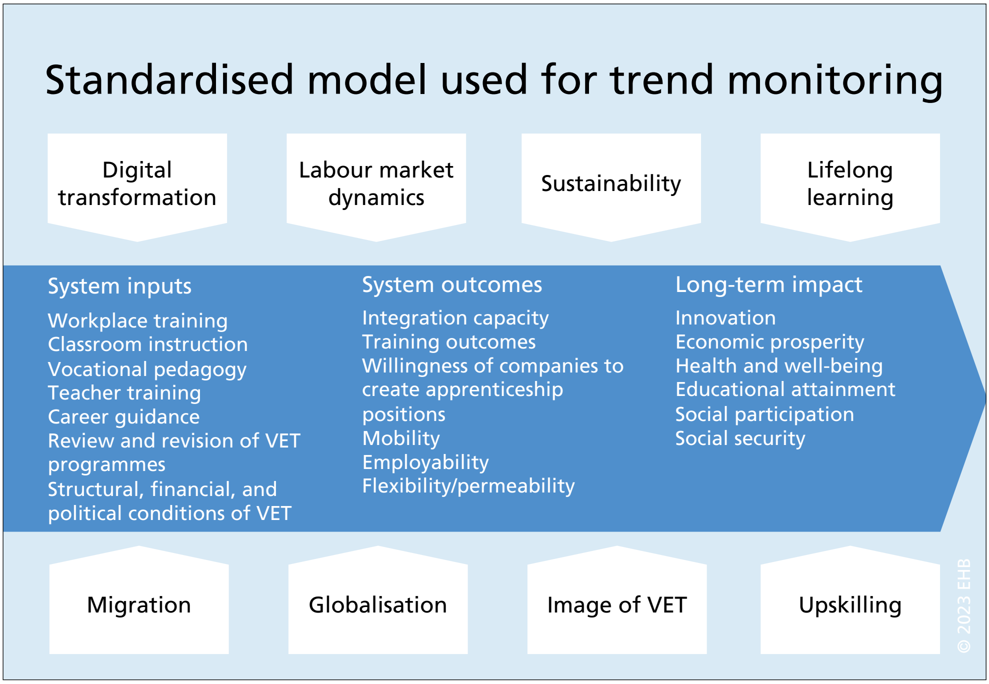
2.2 Monitoring method

OBS SFUVET researchers have developed a standardised model grounded in Swiss and international educational documents of strategic and scientific relevance – such as the *Leitbild Berufsbildung 2030* (Seri 2018), the *Swiss Education Report* (SKBF 2018) and OECD's (2018) *Education at a Glance* report. The model comprises a set of clearly defined analytical categories (see Figure 2), which serve as a common frame for evaluating all sources included in the source pool. The sources are systematically coded according to the categories derived from this model, enabling a structured quantitative and qualitative analysis of trends and developments concerning the Swiss VET system.

The main categories considered in our standardised model are the following:

- **Megatrends:** The identification of relevant megatrends is guided by the strategic documents described above. On this basis, we have identified eight overarching megatrends with potential implications for Swiss VET. The monitoring process places a particular emphasis on developments related to upskilling, lifelong learning, digital transformation, labour market dynamics, the national and international image of VET, globalisation, sustainability, and migration. Additional megatrends will be integrated into the standardised model as they become relevant for VET – minor, more temporary trends are coded in an open category of *other trends*.
- **System inputs:** 'System inputs' are activities undertaken by the federal state actors, the state actors (e.g. cantons), professional organisations, companies, workplace trainers and vocational school teachers in order to achieve important VET objectives. These include workplace training, classroom instruction, the corresponding pedagogical-didactic methods, teacher training, career guidance, review and revision of VET programmes and the structural, financial, and political conditions of VET.
- **System outcomes:** 'System outcomes' are short- to medium-term objectives to be achieved by system stakeholders. Important outcomes include the integration capacity and the flexibility or permeability of the VET system and its programmes. In addition, successful completion of VET and the employability of VET graduates are important system outcomes.
- The **desired long-term impact** of a functioning VET system includes overarching societal values such as innovation, social security, economic prosperity, health and wellbeing, and social participation. They allow for a comprehensive discussion of the monitoring results in terms of the long-term role and future prospects of VET in society.

Figure 2: Standardised model used for the OBS SFUVET trend monitoring

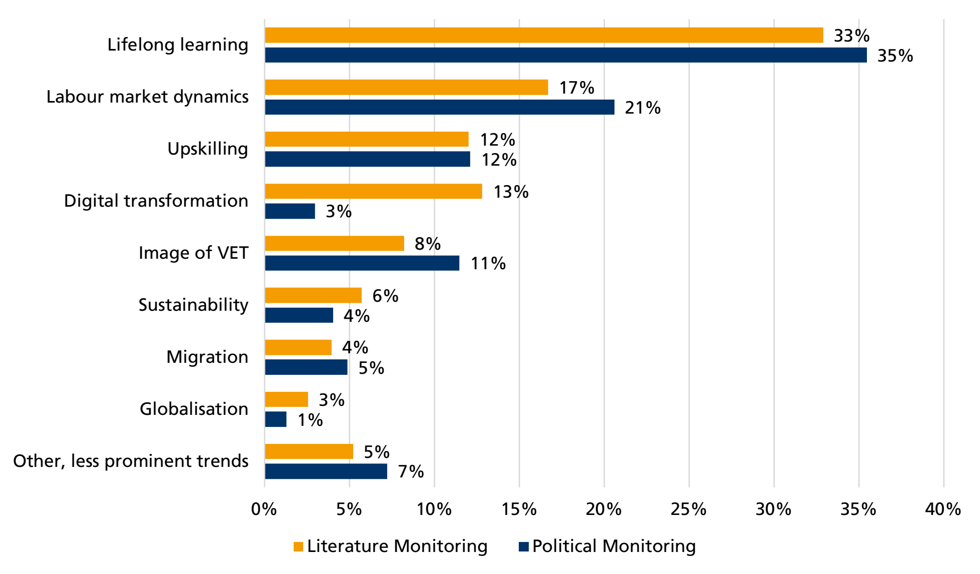


Source: own illustration of standardised model

3 Monitoring results

All articles, reports and policy issues in the source pool are coded into the analytical categories shown in Figure 2 above. This coding forms the basis for our quantitative assessment, for example, for the identification of the most salient megatrends in the VET discourse (see Figure 3) or to examine whether certain key system inputs and outcomes are frequently mentioned in relation to certain megatrends. We complement the quantitative results with a more qualitative evaluation of the source pool to understand how challenges and developments are framed, which VET-related issues are problematised, and how potential solutions are articulated by different actors.

Figure 3: Megatrends in VET – Results from the OBS SFUVET Trend Monitoring 2021 to 2024



Source: own illustration of monitoring results

Notes: This chart provides an overview of how often a particular megatrend is represented in the source pool. Since publications often address more than one megatrend, the chart reflects a multiple-response distribution. The frequency can be understood as an indication of the importance of the megatrend in discussions among researchers and practitioners, $N_{literature\ monitoring}=3022$; $N_{political\ monitoring}=471$

Figure 3 presents key quantitative findings from the literature and the political monitoring for the 2021 to 2024 monitoring periods (autumn 2020 to autumn 2024) and depicts which megatrends in VET are most frequently addressed in the source pool.[4] Overall, the main VET megatrends in both the political monitoring and the literature monitoring are *lifelong learning, labour market dynamics, upskilling*, the *digital transformation*, and the *social image (status) of VET*. The only major difference between the literature and the political monitoring concerns the megatrend *digital transformation*, which is much more prominent in the literature than in policy issues.

To illustrate how the trend monitoring works in practice, the following section focuses on the megatrend **lifelong learning**. This choice is made for illustrative purposes: rather than covering all megatrends in detail, we use lifelong learning as an example to demonstrate how results are analysed and interpreted.

Lifelong learning is often viewed as any education occurring after individuals have completed their formal education and includes aspects such as formal education, informal

4 To ensure a comparable timeframe for the political and literature monitoring, we exclude the earlier monitoring periods 2018 to 2020. Results from this earlier phase, which are only available for the literature monitoring, can be assessed on the OBS SFUVET website. URL: **https://www.sfuvet.swiss/research/obs/trend-monitoring-trends-in-VET** (Retrieved on 12.08.2025).

learning at the workplace or individual skills development (e.g. London 2021). Lifelong learning was the most frequently discussed megatrend in VET in the monitoring period 2021 to 2024. 33 percent of the megatrends discussed in publications (literature monitoring) and 35 percent of the identified policy issues (political monitoring) are related to topics associated with lifelong learning and individual skills development. Lifelong learning is becoming increasingly important given social, economic and digital trends. This has implications for VET, as learners and workers alike need to acquire not only job-specific competencies but also the ability to continuously update and expand their skills throughout their lives. VET plays a crucial role in supporting lifelong learning by enabling adults to obtain vocational qualifications, facilitating the validation of non-formal and informal learning, or providing access to both formal training and informal learning opportunities at work.

Within each megatrend, different expected objectives or outcomes of VET are addressed. In the context of the megatrend *lifelong learning*, our monitoring shows that employability is an important issue. Employability refers both to the type of skills needed to ensure a smooth transition when entering the labour market and to employability throughout a career. Other important system outcomes we identify concern issues such as the successful completion of formal (VET) programmes and aspects of the quality of training. In addition, particularly the political monitoring often addresses the integration capacity of the system, especially in relation to recently arrived immigrants or adults with low basic skills.

Each megatrend may concern different system inputs or areas of activity. We find that lifelong learning is most often addressed in the context of dual and higher VET, school and workplace learning, and issues around (new) teaching and learning methods to deliver lifelong learning content. An important recent issue that is prominently addressed in the political monitoring and concerns the structural and formal conditions of the system is the planned introduction of the formal qualifications of 'Professional Bachelor' and 'Professional Master'.[5]

Overall, the exemplary analysis of lifelong learning illustrates how the OBS SFUVET trend monitoring captures both the thematic breadth and the contextual depth of developments in VET.

4 Discussion

The OBS SFUVET trend monitoring strategy provides a systematic and evidence-based framework for consolidating knowledge about developments affecting VET systems. Its strength lies in the structured integration of qualitative and quantitative analyses, based on a clearly defined coding model and a broad, interdisciplinary source pool (see section 3). The monitoring process does not aim to predict future developments but rather to synthe-

5 In Switzerland, like in Germany, there has been intense debate in recent years about whether to introduce the title supplements 'Professional Bachelor' and 'Professional Master' for higher VET (professional education) qualifications. While these titles were introduced in Germany at the beginning of 2020, they have not yet been implemented in Switzerland at the time of writing, as the legislative process was still ongoing.

sise existing knowledge and identify recurring patterns and thematic shifts that shape VET discourses and practices.

From a strategic governance perspective, the results of our trend monitoring serve as a valuable resource for a wide range of actors involved in the design and implementation of VET. In particular, the three collective VET partners (*Verbundpartner*) in Switzerland – comprising the federal state, the cantons, and professional organisations – can draw on our findings to support evidence-based decision-making and long-term system development. Through our publications, such as Trend in Focus policy papers and Trend Reports, OBS SFUVET provides targeted analyses that help stakeholders to contextualise current challenges and consider their implications for policy and practice.

In addition to its external function, the monitoring also plays an important internal role by informing strategic agenda-setting within SFUVET as a federal university and Switzerland's expert organisation for VET. The knowledge generated by the monitoring activities can be integrated into the institution's strategic planning and development processes. This helps to ensure that SFUVET's activities in VET research, teaching and training, as well as its contributions to occupational development, are forward-looking, evidence-based, and aligned with the institution's mission in VET.

Beyond the national context, policy actors and VET practitioners from various countries can benefit from the trend monitoring as a structured and comparative reference point. While the monitoring is rooted in Swiss institutional arrangements, the inclusion of international sources and the thematic focus on globally relevant issues – such as digital transformation, demographic change, and sustainability – enhance the broader relevance and transferability of the findings. This can support mutual learning processes between countries facing similar systemic challenges.

The research community also benefits from access to a systematically curated body of data that captures how VET is discussed and shaped in different institutional and political contexts. Although the data are currently only available upon request, efforts are underway to make the source pool more openly accessible in the future, thereby enhancing its potential for research.

In terms of limitations, it should be noted that the identification and interpretation of trends are, to a large extent, shaped by their socio-political and institutional contexts, which may limit the generalisability of findings beyond the national context. Furthermore, maintaining the relevance and accuracy of the monitoring system requires regular methodological refinement and critical reflection, which, in turn, may make comparisons over time more difficult.

In conclusion, the OBS SFUVET trend monitoring approach contributes to the consolidation and dissemination of knowledge in the field of VET. Its structured methodology and integrative perspective make it a valuable tool for system actors, researchers, and international observers wishing to engage with the evolving dynamics of VET.

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Sandra Horn and Felix Lukowski

The Research Data Centre at BIBB – Preparing and Providing Data for Social and Economic Sciences

Data reuse is key part of empirical research. It saves time and resources and supports transparency and reproducibility. The Research Data Centre of the Federal Institute for Vocational Education and Training (BIBB-FDZ) provides non-commercial researchers standardised access to data, focusing on vocational education and training. The BIBB-FDZ inspects, anonymises, documents, and archives data from research projects. Data are accessible via Off-site use as: Scientific-Use-File (SUF), Campus-File (CF), Remote Data Access (RDA), or On-site use (GWA). This article gives an overview of the BIBB-FDZ data and the application process for its use. Two longitudinal datasets are presented as examples of individual- and firm-level data: the harmonised BIBB/BAuA Employment Survey on work and education, and the BIBB Establishment Panel on Qualification and Competence Development, providing insights into firm-level training.

1 The role of Research Data Centres in the reuse of research data

Reusing existing data is an essential part of empirical research – both for practical and scientific reasons.[1] The re-usage of data saves time and resources by making it unnecessary to conduct new, often costly surveys. Instead, researchers can rely on high-quality data sets that have already been collected using established methods. Some of these data allow for longitudinal analyses. For example, the BIBB/IAB (Institute of Employment Research [IAB] of the German Federal Labour Office [BA]) and BIBB/BAuA (the Federal Institute for Occupational Safety and Health [BAuA]) employment surveys[2] have elicited workplace tasks every six years since 1979 allowing for analysing changes over a large time span. Particularly when surveying firms, reusing data also helps prevent over-surveying and reduces respondent burden. In addition, existing datasets can often be linked with other sources, opening up new analytical opportunities – for example, by linking survey data with administrative data. Just as importantly, reproducibility and transparency – core principles of good scientific practice – depend on data being findable, accessible, interoperable and reusable.

1 We acknowledge the usage of ChatGPT 5.0 and DeepL in April 2025 for translation and linguistic reasons.

2 For further information on the data sets and the collecting institutions, please read here: **https://www.bibb.de/en/14781.php** (Retrieved on 05.05.2025).

Against this backdrop, Research Data Centres play a crucial role in enabling the secure and efficient reuse of research data. In the following, we present the work of the Research Data Centre at the BIBB (BIBB-FDZ) and show how we contribute to providing high-quality microdata for secondary analysis in a user-friendly manner. A Research Data Centre is an institution that is dedicated to archiving, managing, and disseminating research data. The key task of a Research Data Centre is to ensure the secure storage, long-term archiving, and accessibility of data while complying with data protection regulations. To enable researchers to reuse data, the documentation of the data is essential. According to the German Data Forum, which embodies most public data collecting institutions in Germany,[3] a Research Data Centre must fulfil five mandatory criteria. These criteria are as follows: the data sets offered must be sensitive and add original value for the disciplines. The Research Data Centre must ensure the protection and security of the sensitive data and provide a quality-assured preparation and documentation of the data. Furthermore, a Research Data Centre must offer the institutional prerequisites for an operational business, such as an appropriate IT-infrastructure. At the time of application, the Research Data Centre must provide evidence of at least five contracts[4].

2 Tasks and Workflows at the BIBB-FDZ

The Federal Institute for Vocational Education and Training has the legal mandate to carry out vocational training research according to Section 90 (2) of the Vocational Training Act. On the basis of this mandate, the BIBB collects data from various research projects. The Research Data Centre of the Federal Institute for Vocational Education and Training (BIBB-FDZ) provides access to this high-quality data for non-commercial research to facilitate empirical research. The BIBB-FDZ is accredited by the German Data Forum (RatSWD).

To make the BIBB project data available for reuse, it must be prepared in compliance with data protection laws to ensure that disclosure is permitted. Preparation includes anonymising the data to prevent re-identification of individual observation units. In accordance with the General Data Protection Regulation (GDPR)[5], the risk of re-identification must be minimised to protect personal data and uphold privacy rights.

Moreover, to enable the research to reuse the data, the BIBB-FDZ provides extensive documentation of the data, such as questionnaires, data and methods reports, literature based on BIBB-FDZ data sets. Further preparation includes standardisation of the data (e.g. assignment of standardised missing codes) and enrichment with additional information (e.g. occupations, industries, regions). The BIBB-FDZ offers extensive documentation and provides access to the Metadata Catalogue[6], a platform that contains comprehensive information on the available datasets – including questionnaires, codebooks, and English-

3 Website German Data Forum see URL: **https://www.konsortswd.de/en/about/ratswd/** (Retrieved on 30.04.2025).

4 For the Publication, see URL: **https://www.konsortswd.de/publikation/akkreditierung-und-qualitaets-sicherung-von-fdz/** (Retrieved on 30.04.2025).

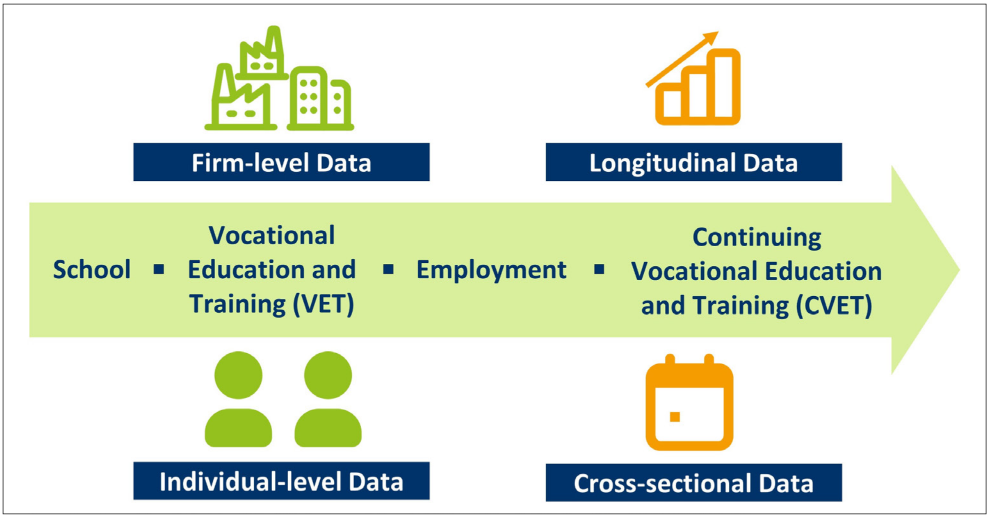
5 For the General Data Protection Regulation, see URL: **https://gdpr-info.eu/** (Retrieved on 30.04.2025).

6 For the BIBB-FDZ Metadata Catalogue, see **https://metadaten.bibb.de/en/** (Retrieved on 30.04.2025).

language materials. The catalogue offers a structured overview of all data sets, categorised by the unit of data collection, distinguishing between individual-level and firm-level data. It is essential for research users to understand how to access the data processed and curated by the FDZ.

The BIBB-FDZ adheres to the FAIR principles (cf. Betancort Cabrera et al. 2020) – Findable, Accessible, Interoperable, and Reusable – when making its datasets available for research, ensuring they can be easily discovered, accessed, integrated into various research contexts, and reused. It also supports long-term data archiving to maintain accessibility for future inquiries. Each dataset receives a DOI – a persistent Digital Object Identifier that provides a permanent link to the data. Assigning and registering datasets in searchable catalogues under their DOIs enhances findability and ensures that research outputs can be linked to the corresponding data sets.

Figure 1: Thematic and methodological framework of research data at the BIBB-FDZ



Source: Own representation using icons from Tabler. Tabler Icons are available under the MIT License (https://tabler.io/license). Copyright (c) 2018–2025 Tabler

The BIBB-FDZ structures its data along an ideal-typical life course framework that reflects key stages in individuals' educational and occupational trajectories (cf. figure 1). Each dataset is systematically categorised according to three dimensions: (1) the specific phase of the life course it addresses, (2) the unit of data collection (individuals or firms), and (3) the underlying survey design (longitudinal or cross-sectional). Thematically, this framework encompasses the transition from school to vocational education and training and from VET to employment, and continuing vocational education and training. Depending on the survey unit, the BIBB-FDZ offers different data sets that allow both cross-sectional and longitudinal analyses according to the research interest.

3 Data access at BIBB-FDZ

The access to the BIBB-FDZ research datasets is standardised and transparent (cf. the FAIR principles outlined in the previous section). The BIBB-FDZ also offers researchers consultations on the choice of feasible data sets for their research question and helps researchers along the publication process whenever question concerning the data arise. The application processes for the use of research data provided by the BIBB-FDZ is transparent and standardised. Data access is usually granted in a timely manner and is free of charge.

Basically, a distinction is made between two different types of data, namely, individual and firm-level data, each of which is associated with different data access paths. The BIBB-FDZ offers four different forms of data access: *Scientific-Use-File (SUF), Campus-File (CF), Remote Data Access (RDA)* and *safe workplaces for guest researchers (GWA)*. The specific data available via each access path varies primarily according to the degree of anonymisation but also according to the manner of data provision (Friedrich/Krekel 2019). Consequently, this also impacts the manner in which data are provided.

Data with individuals as the data survey unit can usually be requested and utilised as an SUF. An SUF is the most frequently used form of data access. In case researchers require access to information excluded from the SUF in the anonymisation process, e.g. full-text information or detailed occupational codes, they could submit an additional application. Comprehensive instructions regarding the application procedure are available on the BIBB-FDZ website. The completed applications for data use can be submitted via regular mail or email.

A special form of data is the CF, this access path has been developed for students (for purposes such as seminar papers or theses), and for use in university teaching (for content analyses or methodology seminars) and is available for individual data. The CF underlies additional anonymisation steps in comparison to the SUF (Friedrich/Krekel 2019). However, this does not affect the informative value of the analyses and is deemed to be optimally for university use.

Firm-level data containing firms or facilities as the fundamental data survey unit are available via Remote Data Access or at safe workplaces for guest researchers on site in Bonn. Remote data processing is primarily designed for analysing establishment data. Firm-level data are generally not offered by the BIBB-FDZ as an SUF due to their higher risk of re-identification. The procedure to analyse data via RDA is as follows: first, the researcher gets access to 'test data', i.e. data that are similar to the originals in terms of structure, items and characteristics, but does not produce any meaningful results. Then this 'test data' is used to programme executable syntaxes (e.g. R, SPSS or Stata), and the researcher sends these syntaxes to the BIBB-FDZ. The BIBB-FDZ applies the syntaxes to the original research data. The output is then checked for confidentiality or risk of re-identification and sent back to the user.

4 Presentation of two longitudinal data sets provided by BIBB-FDZ

In the following, two harmonised datasets are introduced that are specifically designed to facilitate longitudinal analyses and are fully available in English, including both the data and the accompanying documentation. In the following, the harmonised BIBB/BAuA Employment Survey and the BIBB Establishment Panel on Qualification and Competence Development are highlighted as two examples from our range of individual- and firm-level data sets.

4.1 BIBB/BAuA Employment Survey harmonised (H-ETB)

The individual-level data set comprises the BIBB/BAuA Employment Surveys 2006, 2012 and 2018, which are cross-sections of the working population in Germany. The H-ETB comprises 60,048 cases and provides a harmonisation of the variables of the three survey waves. Van Berk and Friedrich (2025) provide an overview of the subject areas and methodology of the harmonised data set. The data encompasses detailed individual-level information on education and qualifications, working conditions, job satisfaction, and health status of employees working at least 10 hours per week. Further information is available at URL: **https://metadaten.bibb.de/en/dataset/detail/203**.

4.2 The BIBB Establishment Panel on Qualification and Competence Development

The firm-level level data set comprises all survey waves of the BIBB Establishment Panel on Qualification and Competence Development in a harmonised longitudinal form. The survey started in 2011 and is the second largest panel survey of firms in Germany surveying around 3,500 firms each year. Friedrich and Lukowski (2023) give an overview of the survey design and the topics covered in the survey. The data provides in-depth information on firms' human resource practices, with an emphasis on vocational and continuing education and training. In addition, the survey includes various thematic areas, such as economic transformation processes – both technological and ecological – as well as refugee integration into the labour market. Further information is available at URL: **https://metadaten.bibb.de/en/dataset/detail/147**.

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Chapter 3: Evidence-Based Adaptation in Times of Transformation

Luiz Eduardo Leao

Evaluating the Acceptance of Adaptive Learning Technology for Learning in Technical-Vocational Education and Training Courses

This study aimed to identify the acceptance of Adaptive Learning technology in the teaching and learning process provided in Technical and Vocational Education and Training (TVET) courses. The study population was composed of students who attended or are attending technical courses at schools in Brazil, considering the last four years as a reference, and who had some experience or knowledge about Adaptive Learning technology. A quantitative survey was applied to 212 students based on the Unified Theory of Acceptance and Use of Technology (UTAUT). The results demonstrated the good acceptance and motivation of students to use this technology in TVET courses, offering evidence-based recommendations that can contribute to reflecting over the adoption of Adaptive Learning technologies in TVET courses.

1 Introduction

Digital, technological, and social transformations, aligned with other global trends and realities such as the economy, demographics, and the green transition, tend to increasingly impact the future of jobs. There will be a greater demand for technological skills associated with human skills such as cognition and collaboration. As a result, the skills gap remains a significant challenge to effectively respond to these global trends and realities (World Economic Forum – WEF 2025). The global workforce will need a considerable number of people to be involved in reskilling and upskilling programmes to prevent business operations from being impacted or collapsing. With Artificial Intelligence restructuring business models, influencing, and accelerating the impact on workers' skills, and requiring constant professional development to ensure that this workforce is prepared and reduce the risk of unemployment or obsolescence, governments, companies, and educational institutions must react urgently. The education sector will have a key role in combating the reduction of these skills gaps and offering pathways for the improvement and creation of new skills that are rapidly growing and in urgent demand (WEF 2025).

Given this scenario, one of the possible paths evaluated and presented in this study is the personalization of education on a large scale using digital technologies, aiming to meet the specific employability and career demands of people aligned with the transformations in the world of work. Understanding each individual's needs, their particularities and skill gaps, and their specific career projections or trends is necessary to reduce the "human cost" of technological transformation (WEF 2025). In this context, digital Adaptive Learning technologies are gaining strength as a viable alternative and response to a scenario of a new industrial revolution that requires agility, rapid learning, and the ability to continuously adapt in complex and constantly changing environments (Schuh et al. 2017).

2 Theoretical Background

2.1 Unified Theory of Acceptance and Use of Technology – UTAUT

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a paradigm designed to elucidate user intentions regarding the use of particular technologies and their subsequent usage behaviour (Venkatesh et al. 2003; Van Der Spoel et al. 2010). The UTAUT consists of four primary determinants of intention and usage, together with up to four moderators of essential relationships. Four constructs significantly influence user acceptance and usage behaviour: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). These constructs are mainly associated with the model's behavioral intention (BI) and actual use of technology (AU). The four primary modifiers in UTAUT are gender, age, experience, and voluntariness of use (Venkatesh et al. 2003; Van der Spoel et al. 2010).

In the realm of educational technologies, some researchers, such as Almaiah et al. (2019) and Criollo et al. (2023), underscore the necessity of considering additional external factors to evaluate student acceptance of technologies in conjunction with the UTAUT analysis, including the influences of social, technological, and quality aspects. In this context, external factors, including perceived compatibility (PCM), self-efficacy (SE), perceived information quality (PIQ), availability of resources (AVR), perceived awareness (PA), perceived trust (PT), perceived security (PSE), perceived utility (PU), and perceived entertainment (PE) enhance the analysis of technology acceptance (Almaiah et al. 2019; Criollo et al. 2023).

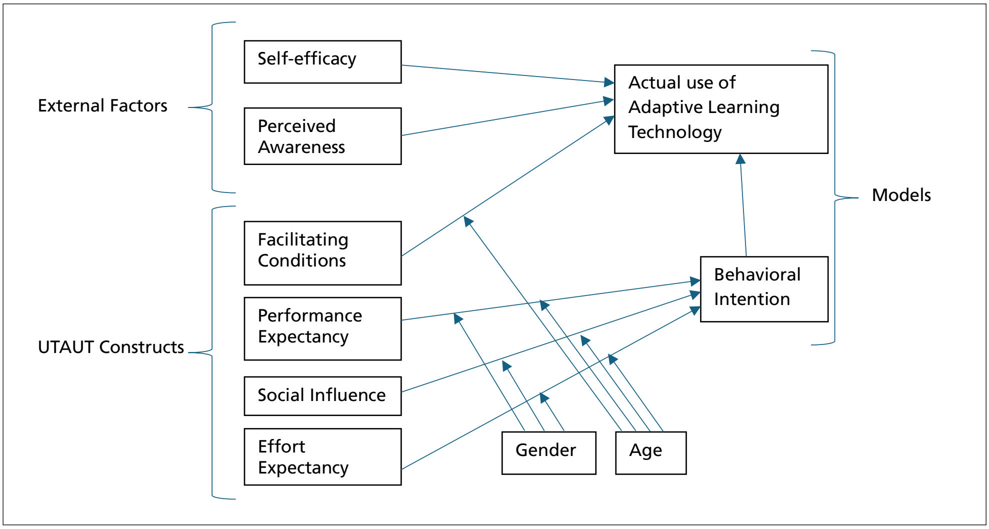
3 Method

3.1 Unified Theory of Acceptance and Use of Technology – UTAUT

According to the research carried out in this study, it was possible to identify some models and questionnaires constructed and validated by several authors, applied in the collection of information for investigation and analysis of the acceptance and intention to use educational technologies that integrate external factors with the UTAUT constructs (Venkatesh et al. 2003; Hamidi et al. 2018; Chavoshi et al. 2019; Almaiah et al. 2019; Criollo et al. 2023). The instrument used for this research corresponds to 16 questions to obtain information about students' acceptance of the use of Adaptive Learning technology in TVET courses. A five-point Likert scale was used to obtain numerical responses based on the following measurement criteria: 1-I strongly disagree, 2-I disagree, 3-I neither agree nor disagree, 4-I agree, and 5-I strongly agree.

In this context, Figure 1 below represents the proposed integrated model, including the aspects of actual use, behavioral intention, gender and age, for an investigation into the acceptance of Adaptive Learning technology by students in TVET courses and to understand how some factors contributed to this perception.

Figure 1: Research model – Unified Theory of Acceptance and Use of Technology (UTAUT)



Sources: Adapted UTAUT model and correlation applied by the author based on ALMAIAH *et al. 2019;* CRIOLLO *et al. 2023;* VENKATESH *et al. 2023*

4 Participants

The study population was composed of 212 students who attended or are attending technical courses at schools in Brazil, considering the last four years as a reference, and who had some experience or knowledge about Adaptive Learning technology. Data collection was performed anonymously from December/2024 to January/2025. A quantitative approach was applied through an online survey.

5 Results

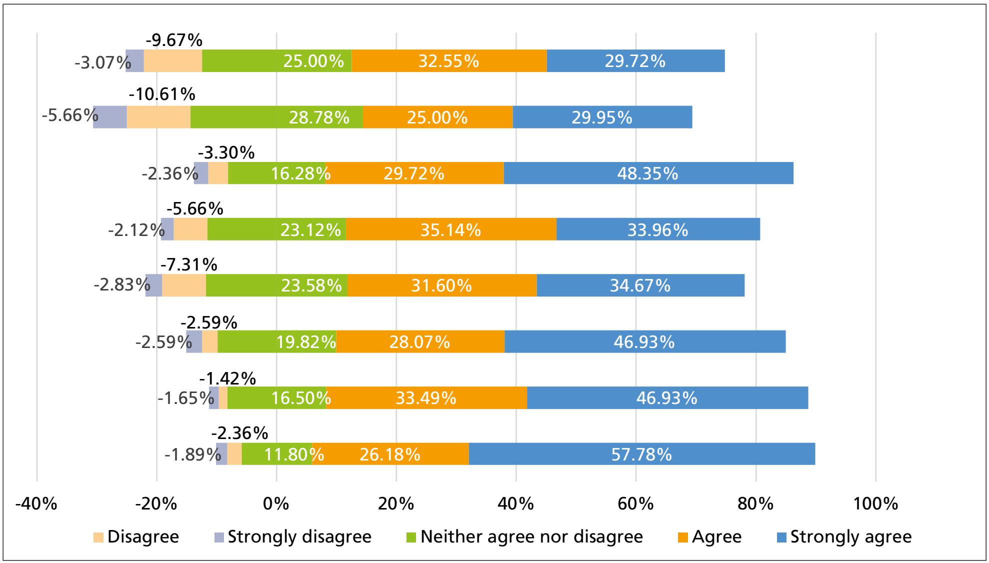
5.1. Results of Adaptive Learning acceptance by students in TVET Courses

Figure 2 presents the research results below. In general, the students accepted Adaptive Learning technology well. The model behavioral intention and perception (BI) obtained the highest percentage, 57.78 percent (strongly agree), where students consider that Adaptive Learning technology will be indispensable in the future (given the advancement of technology) and a valuable solution for teaching. The UTAUT construct, facilitating condition (FC), obtained an identified percentage of 29.72 percent (strongly agree), where students consider they have sufficient resources to use Adaptive Learning technology and the necessary knowledge to apply this resource. However, it is the lowest score in this analyzed field (strongly agree).

On the other hand, it is important to highlight the identified percentage of 5.66 percent (strongly disagree) for the UTATU construct, social influence (SI), where students considered that the teacher or person in authority did not encourage using Adaptive Learning technology for learning. In this same context, the UTATU social influence (SI) construct also obtained a percentage of 10.61 percent (disagree), demonstrating a low perception that anyone close to the students considered that they could learn using this educational technology.

Finally, the external factor self-efficacy (SE) and model behavioral intention and perception (BI) stand out with a percentage (sum of the values of strongly agree and agree) of 83.96 percent and 80.42 percent, respectively, where students evaluated their ability to learn with Adaptive Learning technology and the perception that they would learn more with this technology applied to teaching, added to their belief that with the advance of technology, Adaptive Learning would be indispensable in the classroom and a helpful tool that favors learning.

Figure 2: Student responses to acceptance of Adaptive Learning technology (in %)



Source: own elaboration

6 Discussion

It is important to highlight the results obtained based on the assessment of acceptance and use of Adaptive Learning technology, a model applied and investigated by several researchers (Venkatesh et al. 2003; Hamidi et al. 2018; Chavoshi et al. 2019; Almaiah et al. 2019; Criollo et al. 2023), students showed a significant percentage of acceptance of this technology in vocational education. They demonstrated a high perception of the gains that this technology can present in the development of their skills and add value to the course itself. The results of this study for the UTAUT model also demonstrated the students' perception of the awareness that with the advancement of technology, Adaptive Learning can be indispensable for the classroom. On the other hand, it is worth highlighting the challenges of obtaining the necessary resources to guarantee the full use of this technology, as well as equal access for all, combating digital divide and exclusion (Regec/Regec 2016).

7 Conclusion

One of the current challenges in education is to offer personalized learning experiences in courses with a considerable number of students. Even in cases where there is a considerable number of teachers and mentors, personalized learning can be hampered by limitations in the dynamics of observation in new learning environments proposed by technologies, such as in a blended learning course. In recent years, blended learning courses and using E-learning platforms to enrich the face-to-face classroom have gradually expanded. The question is how teachers now observe students' reactions and how they can intervene assertively in their learning process in these digital education models. Thus, this study sought to investigate whether adaptive platforms can be acceptable by students as additional tools in teaching and learning in TVET. The results showed that Adaptive Learning technologies can indeed be an important and viable ally for vocational education courses.

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Christian Woll

Impact Measurement of Publications in Vocational Education and Training Research – How Does Research-Generated Knowledge Find Its Way into New Research Projects and Political Decision-Making Processes?

Scientists primarily use publications as a means of communication to disseminate and publish research findings. But how can we determine whether insights from scientific publications are incorporated into new research projects or used for political decision-making processes and practical application? Is it even possible to measure the impact of research findings? The present article addresses this question. One chapter explores the understanding of "knowledge transfer" in the context of vocational education and training. Another chapter evaluates methods for the reception of research results within the scientific community, and possibilities of their application in vocational education and training research.

1 Introduction

In times of profound, parallel transformation processes in the economy, politics, environment, and society, and as a result of the continuous changes they bring about, vocational education is also uniquely challenged. The latest Data Report published by the Federal Institute for Vocational Education and Training (BIBB) (BIBB 2024a) as well as the national education report "Education in Germany 2024" (Autor:Innengruppe Bildungsberichterstattung 2024) illustrate this through extensive data and indicator-based analyses. For example, the 2024 data report focused on the topic "Vocational Education and Training in Socio-Ecological Transformation". Vocational education and training research has the potential to support the development of innovative solutions to current challenges (cf. Euler 2025).

Scientists prefer publications as a form of communication to disseminate and publish research results. But how can we determine whether insights from scientific publications are incorporated into new research projects or used for political decision-making and practical implementation? Is it even possible to measure the impact of research results? The short answer is: Yes, but with various limitations.

This article[1] specifies the answer to this question. In chapter 2, the understanding of "knowledge transfer" in the context of vocational education and training is being discussed, introducing the concept developed by BIBB for transferring research and development into policy and practice. In chapter 3, methods for the reception of research results within the scientific community and possibilities of their application in vocational education and training research will be evaluated. Based on this, a literature review of relevant studies is being conducted. In the final chapter, the main results will be summarised and a brief outlook provided.

2 Knowledge Transfer in the Context of Vocational Education and Training

Vocational education and training research is not an end in itself. It rather exists in an area of tension between the demands and expectations of science, practical vocational education and training, and vocational education and training policy. Timmermann (2018) describes this state as follows (author's [CW] translation from the German source)[2]:

"Vocational education and training research occurs between the conflicting logics of science, vocational education and training practice, and vocational education and training policy. Researchers committed to science pursue knowledge gain and seek truth to increase the body of scientific knowledge, while vocational education and training practice (in vocational schools and companies) expects solutions to problems, and vocational education and training policy expects political recommendations [...]. Therefore, knowledge gain, economic usefulness, and political usefulness are in tension, as fundamental insights do not necessarily lead to economic or political utility, and economically (politically) useful insights are not necessarily politically (economically) beneficial" (Timmermann 2018, p. 54).

Ideally, insights gained from research projects are integrated into new research endeavours and various societal areas in a way that they "generate transfer benefits" (DFG 2022, p. 11). Fundamentally, a distinction can be made between two types of research: "fundamental" and "application- or implementation-oriented". While fundamental research primarily aims at gaining knowledge, applied research is designed from the outset to produce results that are as useful as possible for policy, practice, and society (see Ertl/Weiss 2022, p. 4).

For applied research, the major challenge lies in, on the one hand, fulfilling the requirements and expectations placed upon it as best as possible, and on the other hand, meeting the criteria of scientific rigor (see Böhle 2014, pp. 23f.). Therefore, it is important that

1 This is a revised, partially shortened version of the author's article "Can the impact of research results be measured within one's own scientific community? A consideration for vocational education and training research" (Woll 2025), supplemented by the new aspect of "knowledge transfer".

2 The majority of sources referred to in this paper were originally published in German. This applies to all items mentioned in the reference list under the original German title. All titles and all quoted content from those texts were translated into English for this paper, by its author.

applied research, with regard to its problems and questions, establishes a connection to specific socio-cultural, economic, and political frameworks (see ibid., p. 24).

The emphasised importance of transferring knowledge into society, culture, economy, and politics from a science policy perspective is also highlighted by the Science Council in its 2016 published transfer concept (Wissenschaftsrat 2016). In a statement already published in 2013, "transfer" is described as a "core task" of universities and research institutions, as well as one of the essential performance dimensions (besides research, teaching, and scientific infrastructure offerings) of scientific institutions (see Wissenschaftsrat 2013, p. 25). In this context, science communication has also gained relevance in recent years and decades, fulfilling various functions, including "promoting interest in science", "generating understanding of scientific results", "fostering enlightenment", "contributing to education", and "shaping societal dialogue" (Wissenschaftsrat 2016, p. 24).

An important framework condition for the knowledge gain resulting from researchers' publication activities is the principle of "openness", which from a science policy perspective is considered fundamental. The federal and state governments defined this in their joint guidelines on open access in Germany published in 2023 as follows: "Openness to discussion about research questions", "openness regarding the most promising way to solve these questions", and "openness to continually question, discard, or deepen research results" (see BMBF 2023, p. 1).

A central role in the transfer of results from vocational education and training research is played by the Federal Institute for Vocational Education and Training (BIBB). It was founded in 1970 with the goal of regularly and systematically analysing the field of vocational education and training on a scientific basis to develop recommendations for its design. The tasks of BIBB are regulated in the Vocational Education and Training Act (BBiG). BIBB conducts its research activities according to § 90 para. 1 BBiG within the framework of the federal government's education policy. The concretisation of the goals and scope of action of vocational education and training research is outlined in § 84 BBiG. In 2024, an interdepartmental working group developed "Guidelines for the Transfer of Research and Development" at BIBB (BIBB 2024b). This guideline document describes BIBB's understanding of transfer. It outlines dimensions, formats, and activities, as well as fields of action for successful transfer. It elaborates on the philosophy of "science-policy-practice communication" (cf. Esser 2014) and extends the "Guidelines for Scientific Policy Advice" (BIBB 2015). The BIBB guideline defines the institute's understanding of transfer as follows:

"Transfer at BIBB includes the publication and dissemination of scientific findings within the framework of research work, evidence-based advice to policy and practice, as well as application and translation related transfer of vocational education and training-related products and instruments developed or primarily coordinated by BIBB. One goal is to provide 'orientational knowledge' through description, explanation, and evaluation of vocational education and training. Another goal is to promote the socially beneficial shaping of political decisions and practices in vocational education and training through active co-construction of knowledge between science, politics, and practice" (BIBB 2024b, pp. 5f.)

The guideline distinguishes five dimensions of transfer:

1. Co-Construction: this dimension includes activities that start early in the research process and aim to "intertwine science, politics, and practice" (BIBB 2024b, p. 6).
2. Communication: the central means of communication are target group-oriented publications. It is important that not only publication formats aimed primarily at the scientific community are considered but also those that focus on the target groups of vocational education and training planning, vocational education and training practice, and the interested public (see BIBB 2024b, p. 8).
3. Consultation: this dimension describes activities in which the BIBB, based on its scientific expertise, contributes to "conveying knowledge and subsequently preparing and supporting decisions". BIBB's consultancy activities for vocational education and training policy, planning, practice, and the interested public are very diverse (see ibid., pp. 10f.).
4. Application: this dimension involves activities aimed at making scientific findings practically usable for BIBB's various target groups of the. The application-oriented transfer at BIBB mainly takes place within development projects, programmes, and collaborations, as well as through the provision of science-related services and the development and provision of tools and technologies to support practice.
5. Translation: this dimension encompasses additional transfer tasks of BIBB derived from its legal mandate of regulatory work, such as "participating in the development of training regulations and other legal ordinances" (see § 90, paragraph 3, item 1a BBiG). A central transfer task in this context is the development and modernisation of regulatory instruments of vocational education and training (training regulations, training frameworks, and curriculum frameworks) (see ibid., pp. 6 and 13).

For the successful transfer of research findings into political decision-making processes, scientific policy advice plays a particularly important role. In this context, BIBB already adopted and published the "Guidelines for Scientific Policy Advice" (BIBB 2015) in 2015. BIBB's policy advice is directed at "all institutions and actors involved in the field of vocational education and training who act politically and bear responsibility. These are primarily members of federal and state parliaments, federal and state ministries, business organisations and trade unions, but also international/supranational institutions such as the European Commission, OECD, ILO, or UNESCO." (Weiss 2014, p. 90). BIBB understands scientific policy advice as a cross-cutting task that is carried out in various contexts and forms of design, and is largely based on its own research and development work. The forms of policy advice provided by the BIBB are very diverse, ranging from written statements and publications to participation in external committees and system consultancy in international cooperation contexts (BIBB 2015, pp. 2f.).

3 Methods for Impact Measurement

A widely recognised indicator for impact measurement in the literature is (scientific) publications. Therefore, this contribution focuses on publications and their characteristics as objects of investigation. Methodologically, this leads to bibliometrics as the scientific discipline that deals with measuring (scientific) publications using mathematical and statistical methods.

3.1 Bibliometric analyses as a research method for measuring impact

A basic assumption of bibliometrics is that publications are an essential element of scientific communication and, thus, also an indicator of scientific productivity (see Tunger 2022, p. 89). In principle, bibliometric analyses can be used to make statements "about publication output (quantitative), the perception and impact of publications among the scientific community (qualitative), the integration into the scientific landscape, and the international visibility of individuals or institutions in comparison with others (ranking)" (Ball 2006, p. 310).

The two most well-known variants of bibliometric analyses are (see Ball/Tunger 2005, pp. 21f.):

- **Measuring publication volume (output analysis)**: Output analysis determines the total number of scientific publications by individuals, a group of individuals, a working group, an institute, an entire scientific institution, or an entire nation during a specific observation period. Typically, not only journal articles but also a number of other publication types such as books and proceedings are considered. Output analyses can therefore be used to determine, for example, how the proportion of certain publication types has changed over time.
- **Perception analysis:** Perception analysis involves measuring the response generated by publications. Citation analysis is typically used for this purpose. A frequently used indicator is the average number of citations per article (citation rate).

Bibliometric analyses can also serve as a basis for **trend analyses** (observing the temporal development of a topic/scientific field). For example, bibliometric analyses can be used to identify past and present trends in research-relevant topics and evaluate them comparatively. Possible questions include:

- How many articles have been published on a particular topic?
- How has publication behaviour changed over the past few years?
- Which research topics show continuities, and which topics have lost importance in the specialist literature?
- Are there entirely new topics?

In addition to methodology, the question of available data sources plays a central role too as a basis for bibliometric analyses. Woll (2025, pp. 161f.) provides a brief overview of the currently available products, which differ in terms of their scope (e.g., coverage of specific publication languages, sources, or document types), the quality of the metadata, and the available functions of analysis.

3.2 Challenges of Impact Measurement Using Bibliometric Analyses and Possible Alternatives

There are a number of general criticisms regarding the use of citation indicators to measure the impact (resonance) or influence (impact) of published scientific papers. These range from the difficulty of inferring the quality of an individual article from citation frequencies to weaknesses and sources of error at the citation level and the phenomenon of self-citation (see Woll 2011, pp. 44–46). Another problem regarding the use of the two best-known proprietary citation databases – Web of Science and Scopus – is the limited coverage of certain disciplines. This applies to the social sciences and, to an even greater extent, to the humanities (cf. Singh et al. 2021). The problem of underrepresentation can also be applied to vocational education and training research (see Woll 2025, pp. 162–163).

Finally, one of the most widely used indicators for measuring scientific impact, the "Journal Impact Factor" (JIF), has been under criticism for some time (see, for example, Linten/Woll 2023, p. 30 and Frey/Osterloh 2015, p. 142).

This growing criticism of traditional bibliometric indicators, as well as the increasing importance of social media and networks in scientific communication, triggered the development of alternative (complementary) metrics, so-called "altmetrics". These aim to include a broader public in measuring response, in addition to the respective specialist community. In particular, user-generated data (obtained from actions such as mentions, posts, bookmarks, likes, links, or downloads) on the social web are used. A reliable indicator system for altmetrics has not yet been established (see Tunger 2022, p. 91).

3.3 Bibliometric Analyses in Vocational Education and Training Research

Several studies have been conducted in the field of vocational education and training research, employing various approaches to identify topic clusters. Linten/Woll (2013) opted for a hybrid approach combining resonance analysis and thematic trend analysis. The resonance indicator used was the representation of topics in the specialist literature, measured by the frequency of mentioning of keywords in a thesaurus. The data basis was provided by a thematically focused search on publication behaviour in the Vocational Education and Training Literature Database (which was replaced in 2019 by the VET Repository, also operated by BIBB). All reviewed and non-reviewed journal articles for a defined period were taken into account. Two years later, Linten/Woll (2015) published another thematic trend analysis, again based on analysing data of the Vocational Education and Training Literature Database (now the VET Repository). The aim of this bibliometric analysis was to compare countries (Austria, Switzerland and Germany) to determine which topics had a particularly high publication output during the publication period under review (2012 to 2014) and to what extent similarities but also possible "country-specific" trends can be identified between the three countries (see ibid., p. 13).

Two further bibliometric studies traced thematic trends in vocational education and training research based on a content analysis of the "Zeitschrift für Berufs- und Wirtschaftspädagogik" (ZBW, in English: Journal for vocational and business education). The analysis by Tenberg/Eder/Sterrenberg (2009) referred to the articles published in the “Refereed Articles” section between 2000 and 2008. Klusmeyer (2002) based his much more comprehensive content analysis on 20 ZBW volumes (every second volume between 1960 and 1998). Non-refereed articles were also considered to a certain extent. Jahn/Borowski/Götzl (2019) built on Klusmeyer’s (2002) content analysis and examined the extent to which formal, thematic, and social developments continued in the period from 2000 to 2016. Within the framework of two German Research Foundation (DFG) projects (ZI 1152/5–1 and ZI 1152/5–2) on the publication volume in leading German and English-language as well as European and US-American journals of educational science (cf. Ertl et al. 2013), an attempt was made to draw conclusions about the self-image of educational sciences – also in international comparison – using a content analysis of the total of 3,810 articles contained in these journals and in combination with quantitative-statistical methods.

4 Conclusion and Outlook

The literature review in chapter 3 highlights some possible applications for impact measurement in the field of vocational education and training research but also identifies clear limitations. The current and very dynamic developments in the field of artificial intelligence (AI) were excluded. The use of AI could help to at least mitigate existing weaknesses of traditional bibliometrics. A recent literature review identifies the key advantages of using AI in bibliometrics as the automation of data capture, citation analysis, disambiguation of personal names, research impact analyses, and text mining (cf. Saeidnia et al. 2024).

In conclusion, it can be stated that bibliometric methods offer a range of approaches for impact measurement carried out in an academic discipline. However, a major challenge, especially for some disciplines in the humanities and social sciences, continues to be that the citation databases currently available on the market only represent a fraction of the actual publication output. In particular, the relatively new open database OpenAlex could make a valuable contribution to improving bibliometric analysis options in the future. In the field of vocational education and training research, trend analyses on vocational education and training topics or the publication behaviour of the specialist community can be easily implemented using the VET Repository operated by BIBB, which systematically lists German-language specialist literature on all aspects of vocational education and training research published since 1988.

When it comes to measuring the impact of research on policy, bibliometric analyses can provide an initial indicator of the extent to which certain research findings have been reflected in political decision-making processes. However, particular attention must be paid to the selection of data sources. Only data sources that contain an appropriate number of publication types relevant to policymakers should therefore be used.

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Michael Debowy, Jonathan Winter, Gil Epstein, Avi Weiss, and Efrat Behar-Netanel

Trends in Employment and Generative Artificial Intelligence in Israel

Our study focuses on the comprehensive impact of large language models on the Israeli labor market. We match two sets of AI occupation exposure scores (Felten et al. 2023; Eloundou et al. 2024) to workforce survey data from 2023 and 2024 to estimate trends in the distribution of AI exposure as the technology advances. We also extend our analysis to explore the relative potential of LLMs to replace or complement human labor using the AI complementarity measure developed by Pizzinelli et al. (2023), showing that AI exposure has risen fastest in the lowest-complementarity occupations between 2023 and 2024. Finally, we run employment regressions to show that AI occupational exposure scores predict non-employment for lower-complementarity (bottom 60%) occupations even when controlling for all observed covariates and adjusting for worker skills. We interpret this last set of results as rejecting the hypothesis that LLMs have yet to have any impact on the Israeli labor market, though further research is needed to estimate their exact causal effect.

1 Introduction

The rapid advancement of large language models (LLMs) is poised to reshape labor markets worldwide. This paper explores the implications of LLMs on the Israeli workforce by examining exposure trends across occupations and assessing the technology's potential in complementing or replacing human labor, as well as investigating evidence for its already-realized impact.

We build upon our previous work (Debowy et al. 2024), which utilized the AI occupational exposure score developed by Felten et al. (2023), and applied it to the Israeli labor market data, using the AI occupational exposure score developed by Eloundou et al. (2024).[1] This new measure confers two advantages relative to the one used in the previous paper: it is less dated with its technology of reference and it is more easily interpretable, with each occupation's score corresponding to the proportion of tasks typical to that occupation that can be performed by LLMs (either on their own or using additional software and interfaces). In addition, we leverage the AI complementarity metric developed by Pizzinelli et al. (2023) to distinguish between job roles that AI is likely to complement versus those at a clearer risk of replacement.

Matching the exposure and complementarity metrics with the occupational distribution of workers, we are able to map out the potential impact of AI across the entire labor market as well as within and between distinct groups of workers, grouped by factors such as industry of employment, education, gender and ethno-religious group, or geographic

1 The complete version of this paper can be found in Debowy et al. 2025.

location. We also harken back to the exposure measure used by Felten et al. (2023) to estimate the trend in exposure of various occupations, exploring the technological trajectory as a first-best approximation of where we might be headed in the face of uncertainty. Finally, we run employment regressions to explore the contribution of AI exposure to predicting non-employment through different parts of the complementarity distribution in a multivariate setting. Our findings suggest the distinction between complementarity and substitution is crucial in developing policy solutions, that automation and displacement may be more significant than augmentation in the short run, and that developments in generative AI may already be exacerbating unemployment to some extent.

2 Methodology

We use data from the Israeli Central Bureau of Statistics monthly Labor Force Survey. Our representative sample counts some 170,000 person-month observations associated with 42,000 unique persons aged 25–64 from January 2023 to December 2024. We match each such observation with AI exposure and complementarity scores based on their 4-digit ISCO occupation code:[2]

2.1 AI Occupational Exposure Circa 2024

We use the AI occupational exposure score developed by Eloundou et al. (2024), which consists of two scores corresponding to the share of tasks generative artificial intelligence can reliably perform at least 50 percent faster than a human without adversely impacting quality in each occupation. The first score, E1, corresponds to the share of tasks thus performed by LLMs alone. The second score, E2, corresponds to the share of tasks thus performed by LLMs alone or with additional tools, such as image generation. We interpret these as the lower and upper bounds for exposure in 2024, though we focus on E1 to be conservative.

2.2 AI Occupational Exposure Trends

To infer occupational exposure trends, we return to the AI occupational exposure score developed by Felten et al. (2023), which recorded exposure at an earlier date with less advanced technology than Eloundou et al. (2024). We assume that any linear mapping between the two exposure measures corresponds to the change in exposure driven by technological advancement, and thus relative changes between different occupations reflect their relative change in exposure. Since the older measure in Felten et al. (2023) is relative and does not use the same units as our chosen 2024 measure, we must assume some aff-

2 For unemployed or nonparticipating individuals, the occupational code is the one associated with their preferred occupation or their last occupation. 4-digit codes were only available for 89 percent of the employed, 65 percent of the unemployed and 8 percent of the non-participating. We use available 3-digit or 2-digit codes where available instead, based on the average scores of other observations in the 3-digit or 2-digit group.

ine transformation between the scores to retroactively infer the "2023 E1" score. We use a data-driven "least-change" approach to obtain some conservative estimate of this measure, which we interpret as an upper bound on 2023 and thus a lower bound on the 2023/2024 trend.

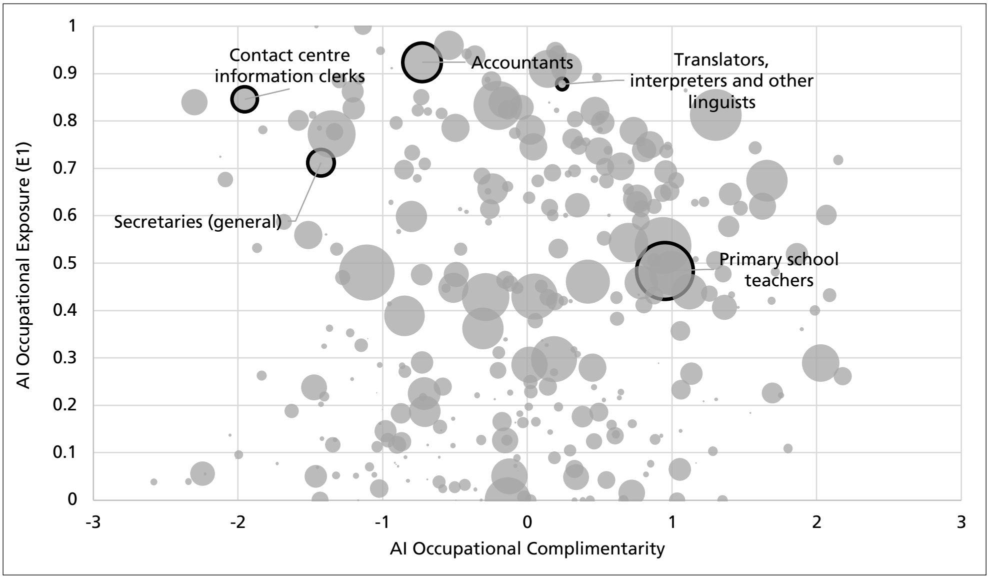
2.3 AI Occupational Complementarity

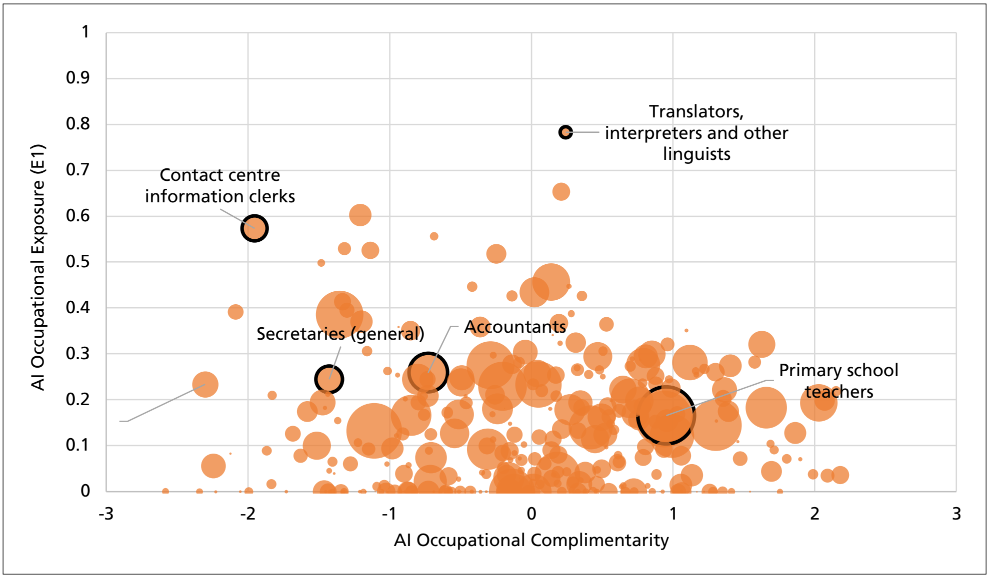
To distinguish between jobs that are being replaced versus those augmented by LLMs, we apply the AI complementarity framework from Pizzinelli et al. (2023). This measure evaluates how well AI integrates into specific occupational tasks, determining whether its role is primarily substitutive or complementary. Occupations with low complementarity are expected to face heightened automation risks, while for occupations of higher complementarity, the effects of AI exposure are more ambiguous.[3] Since the raw metric developed by Pizzinelli et al. (2023) is a relative measure, we group occupations by quintiles to have a clearer view of how complementarity and exposure interact.

After matching the observations with the AI exposure and complementarity scores, we are able to fully map-out the Israeli labor market in terms of the potential impact of generative artificial intelligence. Figure 1 plots each occupation in terms of its complementarity (vertical axis) and exposure (horizontal axis) in 2024, with the size of each point corresponding to the relative weight of the occupation. We find that, during 2024, the average worker has an exposure score between 0.17 (E1) and 0.51 (E2). Workers with exposure scores higher than 0.5 amounted to between 2.4 percent (E1) and 48.3 percent (E2) of the population, suggesting significant potential impacts.

3 The productivity gains of AI in high-complementarity occupations may lead to higher or lower demand for these occupations depending on the exact production structures in which they are utilized and the complementarities between them and other inputs. See Acemoglu (2025) for more detail.

Figure 1: AI exposure (E1 and E2) and complementarity in Israel, ages 25–64, 2024





Source: DEBOWY *et al. 2025*

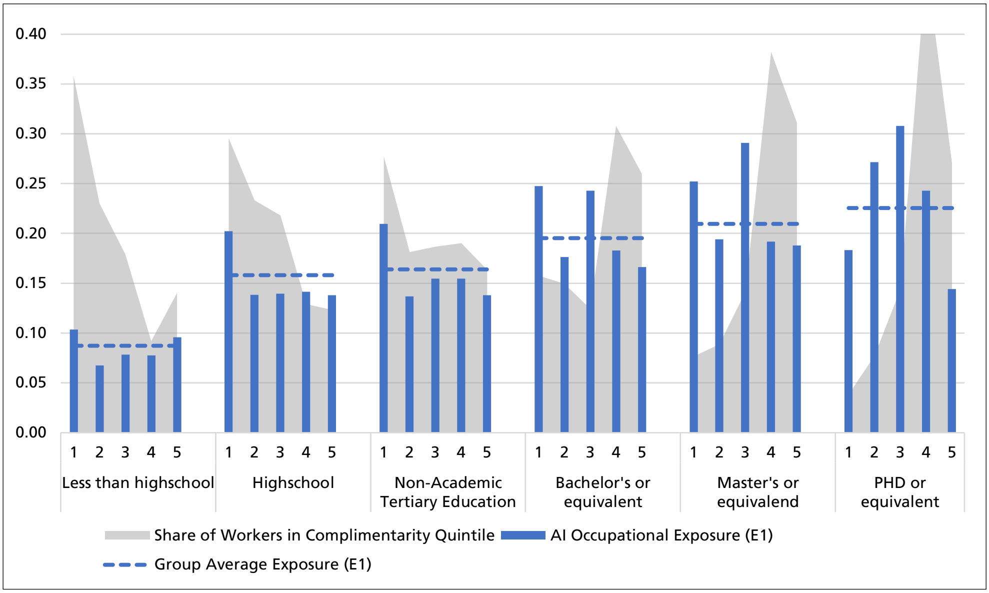
2.4 Additional Groupings of Complementarity and Exposure

To further understand potential policy implications of AI exposure, we investigate the aggregate scores of different groupings of workers, relying on additional information provided by each respondent in the Labor Force Survey.

Let us explore such a grouping by economic industry. For each industry, we measure the average occupational exposure (E1) for each quintile of complementarity (quintiles are fixed and determined by the general population). The most at-risk industry is finance, where the average exposure score (E1) is almost 0.3 and more than 50 percent of employees work in occupations in the bottom two quintiles of the complementarity distribution (i.e., the 40% of occupations at the greatest automation risk). Other industries with a large proportion of workers in low-complementarity occupations include commerce and manufacturing, though the average AI exposure of those workers is notably lower than that of finance workers.

In a similar exercise, we group observations by educational attainment. Figure 2 presents these averages, as well as the relative share of workers in each complementarity quintile for each educational category (and the total average obtained by weighting the conditional averages accordingly).

Figure 2: AI exposure (E1), by industry and complementarity quintile, ages 25–64, 2024



Note: The horizontal lines represent the average within each sector. The complementarity quintiles range from 1 (low complementarity/high substitutability) to 5 (high complementarity). The volumes shown for the complementarity quintiles ("percent of workers in the quintile") are uniform across each quintile, and the distribution illustration is not continuous as presented but discrete.

Source: Debowy et al. 2025

While aggregate exposure is increasing with education, so does the proportion of workers in higher-complementarity occupations. For instance, 16 percent of workers with a Bachelor's Degree or equivalent engage in occupations at the bottom complimentarily quintile (highest automation risk), while among workers with a high school diploma the proportion is

30 percent – despite the fact that the average exposure score is higher among the former group than the latter. This finding casts doubt on the claim that generative artificial intelligence poses more of an automation risk for highly-educated workers, and suggests that better education might alleviate some of the automation risks of this technology, at least as it stands now.

Furthermore, we group observations by gender and ethno-religious group to look at different populations, showing that women are more exposed than their male counterparts both in the overall population and within each ethno-religious group, and that Arab Israelis are less exposed than their Jewish (and otherwise non-Arab) counterparts both in the overall population and within each gender. These differences suggest that issues of equity and inequality may be central to any relevant labor market policy, as the exposure and complementarity measures map onto existing determinants of inequality such as gender and nationality, determinants that are already central in policy discussions in Israel.

3 Trends in Occupational Exposure

Using the AI exposure score developed by Felten et al. (2023), we estimate a hypothetical E1 exposure score for each occupation in 2023, which corresponds to earlier capabilities of LLMs. We thus assume a linear mapping between the two exposure scores, which reflects the change in technological capabilities. For relative changes in occupational exposure, the specifics of the mapping are largely irrelevant, so we focus on these changes as they require no further assumptions. For policy completeness, we suggest a specific mapping that shifts the Felten et al. (2023) score to align with the E1 score at the minimum (0) and scales it to align with the E1 score at the median, based on a conservative principle of "least change" coupled with the assumption that the average score does not decrease between consecutive years. This results in an average hypothetical E1 score of 0.12 in 2023, 0.05 lower than 2024 (almost all of the effect results from the changes in scores, whilst the occupational compositional effect is negligible).

In terms of relative trends, differences are pronounced. The exposure scores of workers in the bottom complementarity quintile increased more than twice as much as those in the top quintile, suggesting that capabilities of generative artificial intelligence are thus far evolving in such a way as to replace human workers more than to compliment them. Further breaking the trend down by gender, we find that some of the gaps reported in the previous section are growing, as the average exposure of women increased more than that of men. We additionally discover that exposure has increased especially rapidly in the finance; public administration and defense; commerce; arts and entertainment; high-tech; and health and social work industries. For all of these industries, except arts and entertainment, the lion's share of the increase came from lower-complementarity occupations.

4 AI Occupational Exposure, Complementarity and Employment

Given the trend of increasing AI exposure – concentrated in lower-complementarity occupations – we seek to examine whether the impact of artificial intelligence on employment has moved from theoretical to real. To that end, we conduct multivariate analysis using Logit employment regressions to examine the extent to which exposure and complementarity are predictors of non-employment among Israelis aged 25–64 given all other observable characteristics. These include age, education, gender and ethno-religious group, district of residence, economic industry and measures of individual-level impacts of the ongoing Israel-Hamas War, such as whether the individual resided in an evacuated town or city and their cumulative absence from work on account of service in military reserves.

Since this analysis hopes to estimate equilibrium outcomes of the technological shock, we move away from scores based on reported occupations and use an adjusted AI exposure score corresponding to the weighted average score of all individuals in occupations with similar skills requirements.[4] Armed with our new measure of AI exposure, we estimate the effect of increasing exposure on employment in each complementarity quintile separately.

Figure 3 presents population-averaged predicted probabilities of non-employment as a function of AI exposure (E1) in 2024. The five separate curves represent the estimates for the five quintiles of the complementarity distribution. The probability of non-employment dramatically increases with exposure for the three bottom quintiles, associating a 0.1 increase in exposure with a .02-.04 pp increase in the probability of non-employment. For the top two quintiles, the relationship between exposure and employment is not statistically significant at the 5 percent level.

4 See URL: **https://esco.ec.europa.eu/en/about-esco/publications/publication/skills-occupations-matrix-tables** (Retrieved on 29.09.2025). We use Matrix 2.4 from version 1.2.0. Based on a vector of 74 reported skills for Each occupation *i* (*Si*), we calculate the Euclidean norm between each pair of occupations. We then define the "proximity" or "similarity" of each occupation pair *i*,*j* as:

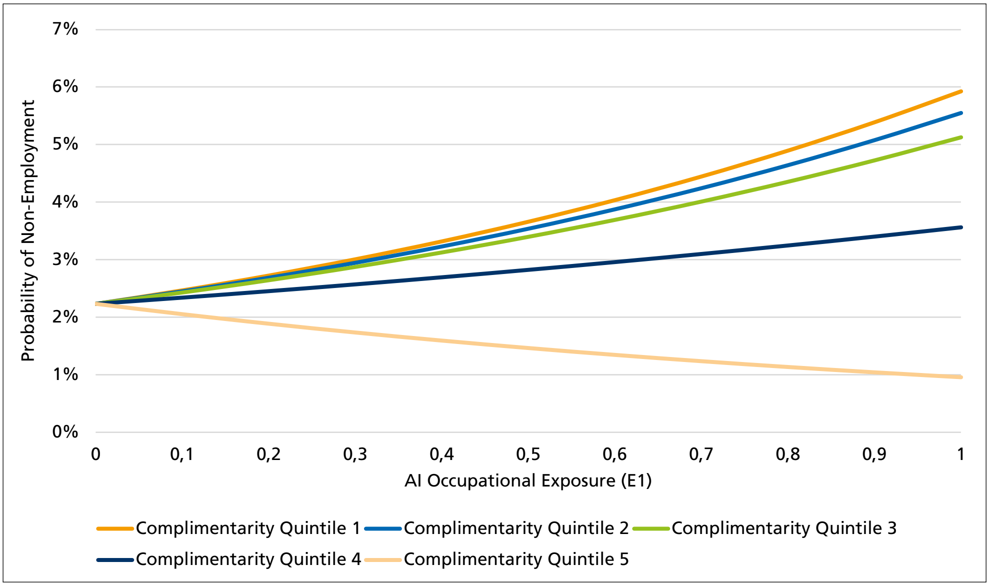
$$d_{ij} = \frac{ln\left(\left\|\boldsymbol{S}_i - \boldsymbol{S}_j\right\|\right)}{\sum_{j=1}^{N} ln\left(\left\|\boldsymbol{S}_i - \boldsymbol{S}_j\right\|\right)}$$

And the new skills-adjusted measure of occupational exposure for occupation *i* as:

$$\mathbb{y}_i^{skills} = \sum_{j=1}^{N}\left(d_{ij} w_j \mathbb{y}_j\right)$$

Where $\mathbb{y}_j$ is the raw exposure score of occupation *j* and w_j is the occupation's relative weight in the labor force.

Figure 3: Probability of being unemployed or discouraged from job search, by exposure index (E1) and complementarity quintile, skill-adjusted indices; ages 25–64, 2024



Note: Controlling for various educational, demographic and geographic factors. Complementarity quintiles range from 1 (low complementarity/high substitutability) to 5 (high complementarity). The markers indicating the average values for 2023 and 2024 represent the predicted employment probability for a hypothetical worker whose exposure level equals the average across the labor market, calculated using the 2024 regression coefficients.

Source: Debowy et al. 2025

These results show that AI occupational exposure scores are a meaningful predictor of non-employment – even conditional on confounding factors – and that the distinction between low-complementarity and high-complementarity occupations is crucial for this relationship to be clearly estimated. Along with the replacement trends discussed in the previous section, we interpret these results as rejecting the hypothesis that LLMs have yet to have *any* impact on the Israeli labor market. It should be noted, however, that the measured effect results mostly from changing AI exposure scores and not from changing compositions of the employed or unemployed population – meaning that they reflect increased automation of jobs and skills that characterized the unemployed population to begin with, exasperating pre-existing worker surpluses rather than creating new ones. Further research is needed to adequately identify causal effects and measure the realized or potential impact of LLMs on employment, structural or otherwise.

5 Discussion

This study has limitations. First, it maps exposure to generative AI based on recorded occupations (based on a more-than-decade-old classification), blurring distinctions that may exist in the real world between different types of workers (high school teachers of different subjects, for instance). Additionally, we cannot track AI's actual implementation or its precise effects on work processes, including task restructuring or the creation of new jobs. It must also be noted that we focus on generative AI to the exclusion of other AI technologies that could significantly affect employment. For example, autonomous systems are expected to replace most commercial drivers and heavy machinery operators (over 5% of the workforce as of 2024) by the late 2030s, yet this form of automation is not accounted for by the metrics we use.

The rapid technological advancement of generative AI also limits the long-term relevance of our findings. Our latest exposure metric may already be outdated, though we hope our analysis of trends may indicate where the technology is headed in the short-run. Finally, the complementarity of AI in various jobs is fluid. Roles where AI currently enhances human work may soon be automated due to technological advances. This uncertainty highlights the need for continuous monitoring of AI's evolving impact on employment.

Methodological limits notwithstanding, our findings highlight the need to monitor and investigate the adoption and assimilation of AI technologies in the workplace, as well as its effects on productivity and employment. In addition, our employment regressions seem to suggest that decisive action may be needed soon to address underemployment among workers in the lower 60 percent of the complementarity distribution – a population that is disproportionately non-college-educated (and skews slightly female). Industries that may unload significant portions of their workforce in the near future include finance (where the transition seems to have already begun), retail and real estate, and to some extent public administration and health and welfare as well. Further research is needed to devise exact policy measures best alleviating the possible displacement of workers in those industries, but likely components include retraining and investment in high-productivity industries.

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Shaza Mohamad Bassam AlHalabi and Khalid Hussain

Harnessing AI for Personalized Learning Pathways in Vocational Education and Training: A Data-Driven Approach to Improved Outcomes

Vocational Education and Training (VET) systems aim to prepare workers for evolving labour markets with challenge as standardized approaches failing diverse learners and causing high dropout rates. This study presents an AI-powered framework for personalized VET learning, integrating machine learning and predictive analytics to address three core challenges: varied foundational knowledge, condensed timelines, and industry-relevant competency development. The system analyses performance metrics and engagement data to create dynamic learning pathways, with instructor dashboards identifying at risk students and competency gaps. Initial results show promise in reducing attrition while improving skill mastery. The research emphasises ethical implementation through robust data protection and bias mitigation, offering a scalable model for VET modernization in the Industry 4.0 era.

1 Introduction

The Fourth Industrial Revolution has fundamentally reshaped labour markets through rapid advancements in AI, automation, and digitization, creating an urgent need for workers who possess both technical expertise and adaptive skills (Trenerry et al. 2021). Countries like the UAE have responded with initiatives such as Economic Vision 2030, which seeks to transition to a knowledge-based economy by developing VET systems that can deliver competencies in emerging fields, including AI, robotics, and sustainability (Hao et al. 2023). However, traditional VET models continue to struggle with structural rigidity, resulting in alarmingly high dropout rates that reach 40 percent in MENA regions due to outdated curricula and student disengagement (UNESCO 2023). This crisis is compounded by significant skill gaps, with 60 percent of UAE technical firms reporting difficulties in hiring workers with adequate AI and IoT capabilities (Abu Dhabi Chamber of Commerce 2023).

Current VET systems face two critical and interrelated challenges that undermine their effectiveness. First, dropout rates remain persistently high, with UAE institutions reporting 14 percent attrition during the first semester alone, primarily due to ineffective teaching methods and insufficient student support (ACTVET). Second, there exists a growing disconnect between VET curricula and actual industry requirements, evidenced by the fact that 35 percent of UAE engineering graduates need additional certifications to meet employer expectations. This misalignment stems from curricula that fail to incorporate cutting-edge technologies like 3D printing, coupled with assessment systems that prioritize theoretical knowledge over practical application. The economic impact of these shortcomings is substantial, with OECD estimates suggesting they reduce national productivity by up to 6 percent of GDP.

To address these systemic issues, this study proposes an AI-driven framework designed to enhance VET outcomes through personalized learning solutions. The framework incorporates three key components: early risk detection systems to identify and support at-risk students through indicators like attendance patterns; adaptive learning platforms that tailor instruction to both individual needs and industry demands; and real-time data analytics to inform continuous curriculum improvements. By leveraging AI technologies, this approach ensures dynamic alignment between educational content and evolving labour market requirements. The framework builds on established educational technologies including machine learning for performance prediction, predictive analytics for student risk assessment, and educational data mining to optimize teaching strategies (Alhakami et al. 2020). While AI applications have become increasingly common in higher education, their adoption in VET systems remains limited, representing a critical gap that this study seeks to address.

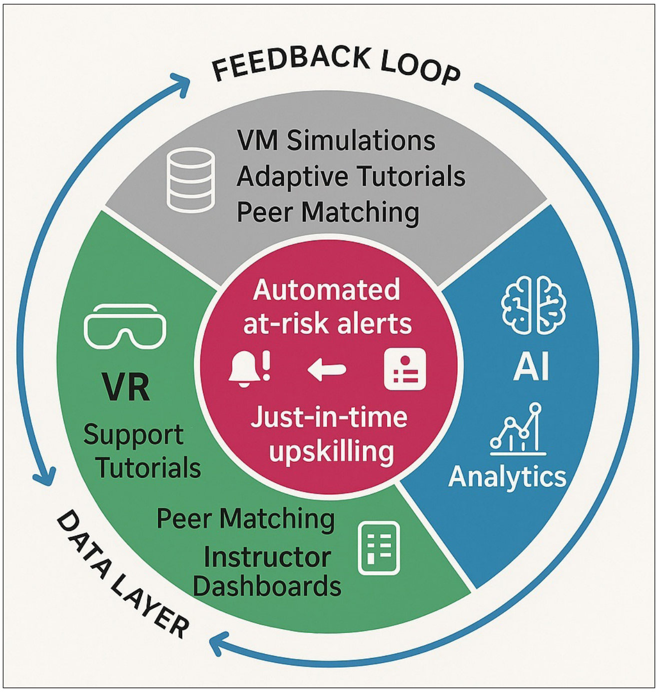
The proposed model introduces several innovations specifically designed for vocational education contexts. It emphasises industry-validated skill development in areas such as precision welding and AI diagnostics while incorporating micro-credentials that allow for modular, stackable certification (Berkling et al. 2023). This approach not only enhances the relevance of VET programmes but also provides learners with flexible pathways to career advancement. By integrating real-time labour market data and AI-driven personalization, the framework aims to create a more responsive and effective VET ecosystem. The ultimate goal is to reduce skills mismatches, improve educational outcomes, and boost economic productivity through closer alignment between training programmes and employer needs. This research contributes to both theoretical understanding and practical implementation of AI in vocational education, offering a scalable solution to the challenges posed by the Fourth Industrial Revolution.

2 Literature Review

The integration of artificial intelligence (AI) into vocational education and training (VET) presents transformative potential but requires tailored approaches to address sector-specific challenges. AI-driven education relies on three core components: machine learning (ML) for adaptive content delivery, predictive analytics for early identification of at-risk learners, and educational data mining (EDM) to uncover hidden insights (Amdan et al. 2024). ML enables dynamic adjustments to instruction based on real-time performance data, such as quiz scores and lab outcomes, ensuring personalized learning pathways. Predictive analytics leverages engagement and performance trends to flag students at risk of dropout, allowing for timely interventions (UNESCO 2023). Meanwhile, EDM extracts actionable insights from diverse datasets, such as VR simulation effectiveness in healthcare training

However, VET systems face unique challenges, including diverse learner cohorts with varying foundational knowledge, condensed instructional timelines, and the need for alignment with rapidly evolving industry demands (Kamalov/Gurrib 2023). AI can mitigate these issues through granular learner profiling, microlearning modules, and real-time labour market analysis. A proposed conceptual framework (Figure 1) integrates AI components with VET's operational realities, emphasizing data aggregation, adaptive analytics, and continuous feedback (Borna et al. 2024). Ethical considerations, such as algorithmic bias and data privacy, must also be addressed to ensure equitable implementation (Abujaber/Nashwan 2024).

Figure 1: AI-VET Integration Framework



Source: Developed by the authors based on ACTVET Institutional Research Report (2023); ©ACTVET

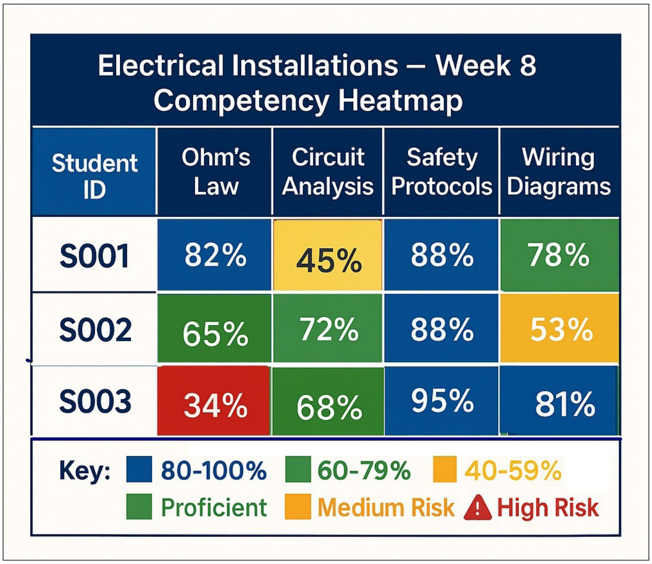
The theoretical underpinnings of AI in VET draw from multiple perspectives. This comprehensive skills development vision aligns with the EU Skills Agenda (2021 to 2030) which emphasises upskilling for economic resilience, while human capital theory frames education as an investment in productivity (Schultz 1960). Behaviorist principles align with AI's automated feedback mechanisms (Skinner 1986), and connectivism highlights the role of digital networks in modern learning (Siemens 2005).

3 Framework Design

The proposed AI-driven personalized learning framework integrates multiple data sources from ACTVET's strategic initiatives and promising practices to create a comprehensive system for vocational education (ACTVET Strategy, 2020 to 2024). As shown in Figure 2, the architecture builds on successful implementations like the Arduino Innovation Hub (ACTVET Promising Practice Submission – Arduino Innovation Hub) and Paramedic Virtual Simulation Lab (ACTVET promising practice paramedic virtual simulation lab), incorporating three interconnected components. The system collects diverse data including enrolment patterns from ACTVET's TVET database (ACTVET promising TVET database), assessment scores, IoT-enabled lab performance metrics, attendance records, and weekly learner satisfaction surveys.

The AI modules leverage insights from ACTVET's AI Strategy (ACTVET AI Strategy v1-1162024), featuring an Early Warning System that reduced dropouts by 40 percent in pilots and an Adaptive Intervention Engine that improved practical exam scores by 22 percent through VR simulations (ACTVET promising practice). User interfaces incorporate lessons from these implementations while maintaining GDPR compliance through robust anonymization protocols. Continuous improvement mechanisms align with ACTVET's strategic goals of industry-responsive curriculum development (ACTVET MAIN Strategy English 2024), ensuring the framework remains at the forefront of vocational education innovation.

Figure 2: Heatmap of Student Performance Gaps in Electrical Installations


Electrical Installations – Week 8 Competency Heatmap

Student ID	Ohm's Law	Circuit Analysis	Safety Protocols	Wiring Diagrams
S001	82%	45%	88%	78%
S002	65%	72%	88%	53%
S003	34%	68%	95%	81%

Key: 80-100% 60-79% 40-59%
Proficient Medium Risk High Risk

Source: Authors' elaboration based on ACTVET LMS performance analytics (2023); ©ACTVET

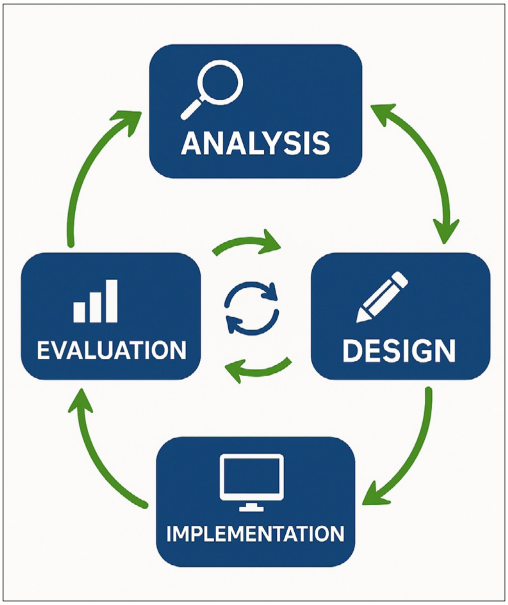
4 Methodology

This mixed-methods study evaluates an AI-driven personalized learning framework across Abu Dhabi's VET system using design-based research (DBR) methodology (Figure 3). Key findings demonstrate the framework's effectiveness: (1) Significant reduction in dropout rates across programmes (e.g., Automotive Repair decreased from 15 percent to 10 percent, Figure 5); (2) Improved exam pass rates (up to 92% in Digital Manufacturing, Table 1); and (3) Enhanced student satisfaction. Quantitative analysis of three cohorts (2022 to 2024) revealed these outcomes through SPSS-based statistical testing, while qualitative data from 200 students and 30 instructors provided nuanced insights into implementation challenges and successes. The study employed rigorous ethical safeguards including GDPR-compliant data anonymization and quarterly bias audits (Table 3). Three critical success factors emerged: (a) The iterative DBR approach enabled continuous refinement; (b) AI-powered early warnings reduced attrition by 40 percent in pilot programmes; and (c) Integration of practical skill tracking (via IoT lab equipment) with theoretical assessment created holistic competency profiles. These results, supported by both statistical evidence and participant feedback, validate the framework's potential to transform vocational education while highlighting areas for improvement, particularly in technical infrastructure and user training.

Key Points Incorporated:

1. Mixed-methods design validity
2. DBR methodology (Figure 3)
3. Quantitative outcomes (Tables 1, Figure 6)
4. Qualitative insights
5. Ethical protocols (Table 3)
6. Implementation challenges/successes
7. Statistical significance
8. Practical applications
9. Future improvement areas

Figure 3: Design-Based Research Cycle in AI-VET Implementation



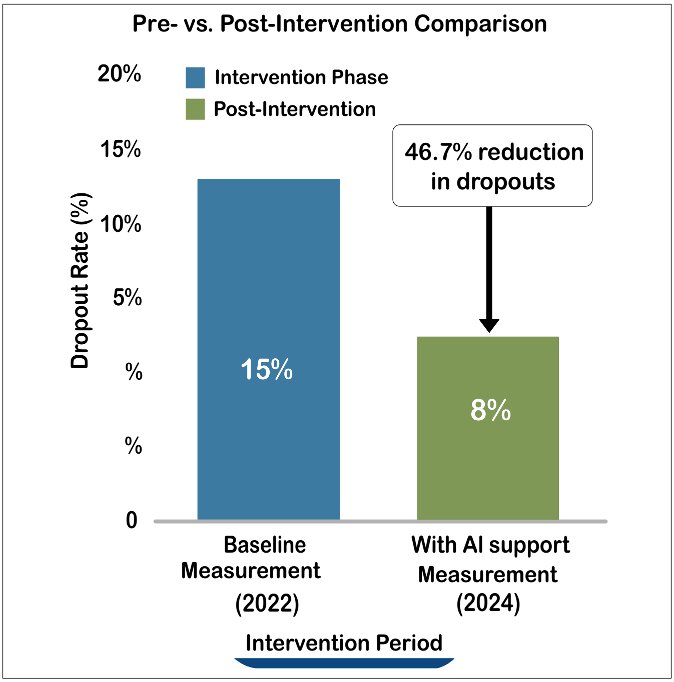
Source: Authors' elaboration based on Design-Based Research protocol, ACTVET Pilot Study (2022–2024); ©ACTVET

Table 1: Pilot Study Overview (2022–2023) (in %)

Programme	Students (n)	Dropout Rate (Pre)	Dropout Rate (Post)	Exam Pass Rate (Post)
Automotive Repair	150	15%	10%	88%
Digital Manufacturing	120	13%	8%	92%
Healthcare Support	90	14%	9%	85%

Source: ACTVET institutional data (2022–2023)

Figure 4: Dropout Trends in Automotive Repair Programme (2022–2024)



Source: Authors' elaboration based on ACTVET Student Information System (SIS) enrollment records (2022–2024); ©ACTVET

Table 2: Ethical Protocol Summary

Protocol	Implementation Example
Informed Consent	Opt-in forms translated into Arabic and English
Data Anonymization	Names replaced with codes (e.g., S001, S002)
Bias Audits	Monthly reviews of recommendation fairness

Source: Authors' elaboration based on ACTVET guidelines, own representation

5 Results

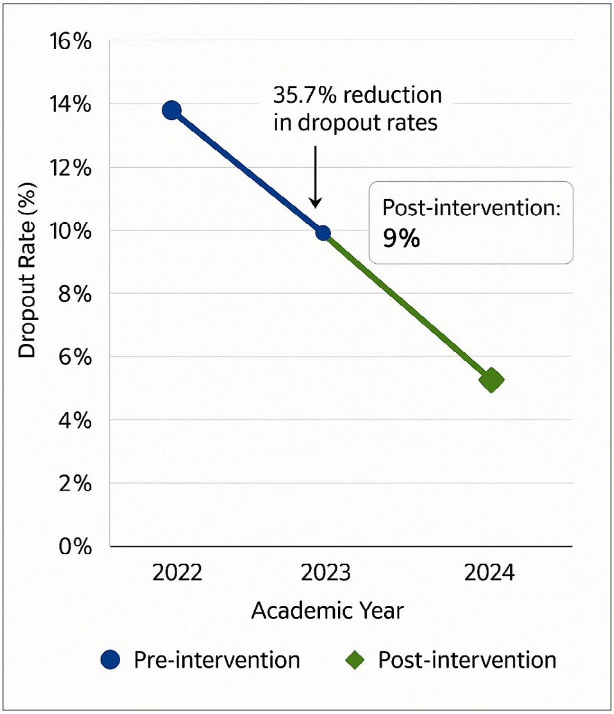
The AI-driven framework demonstrated significant improvements across all 12 VET programmes (Table 4), reducing first-semester dropout rates from 14 percent on 2022 to 9 percent on year 2024, with particularly strong results in Digital Manufacturing (38.5% reduction) and Healthcare Support (35.7% reduction) (Figure 5).

Table 3: Dropout Rates by Program (2022–2024) (in %)

Programme	Pre-Intervention (2022)	Post-Intervention (2024)	Reduction (%)
Automotive Repair	15%	10%	33.3%
Digital Manufacturing	13%	8%	38.5%
Healthcare Support	14%	9%	35.7%

Source: ACTVET institutional data (2022–2024)

Figure 5: Dropout Rate Trends (2022–2024)



Source: Authors' elaboration based on aggregated institutional data from 12 VET programs, ACTVET (2022–2024); ©ACTVET

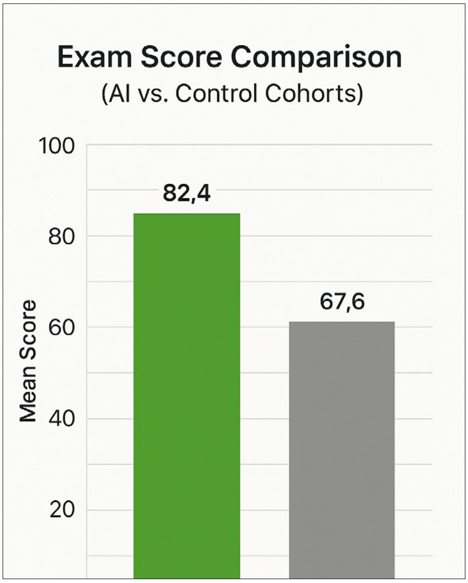
Quantitative analysis revealed AI-supported cohorts outperformed controls by 15 to 25 percent in final assessments (Table 4, Figure 6), with the largest gains in practical skill modules.

Table 4: Exam Performance by Programme

Programme	AI Cohort (Mean)	Control Cohort (Mean)	Improvement (%)
Automotive Repair	84.5	70.2	20.4%
Digital Manufacturing	88.1	73.8	19.3%
Healthcare Support	85.0	68.0	25.0%

Source: ACTVET standardized competency assessment data (2022–2024)

Figure 6: Exam Score Comparison (AI vs. Control Cohorts)



Source: Authors' elaboration based on standardized competency assessments, ACTVET (2022–2024); ©ACTVET

Qualitative data from instructors (Table 5) highlighted improved intervention targeting (80% approval) and time savings (65% reported 5 to 7-hour weekly reductions), though 25 percent noted technical challenges with VR implementation. Student feedback (Table 6) showed increasing satisfaction (3.2 to 4.1/5) with 75 percent valuing personalized recommendations, particularly VR simulations for complex tasks. The synthesis revealed important correlations: students completing >75 percent of AI recommendations scored 22 percent higher, while bias mitigation efforts reduced STEM gender gaps by 18 percent. Limitations included geographic specificity to urban Abu Dhabi and technology dependencies in rural areas.

Table 5: Instructor Feedback Themes (in %)

Theme	Example Quote	Frequency (%)
Improved Targeting	"I can now prioritize students needing urgent help".	80%
Technical Challenges	"VR tools occasionally overload our network".	25%
Workload Reduction	"AI-generated reports save 5–7 hours weekly".	65%

Source: ACTVET instructor focus group data (2022–2024)

Table 6: Student Feedback Highlights (in %)

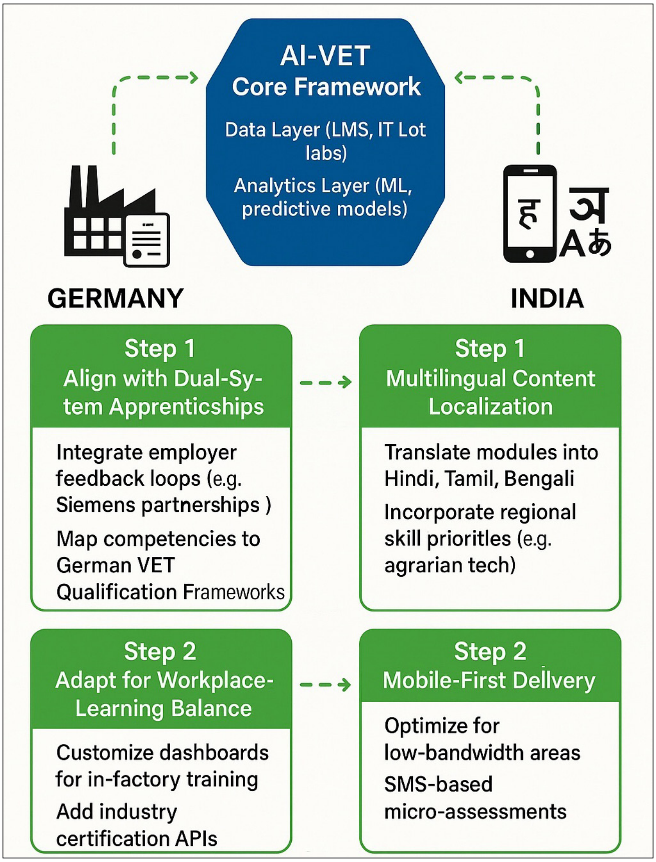
Aspect	Positive Responses (%)	Critical Responses (%)
AI Recommendations	75%	12%
Dashboard Usability	68%	20%
Content Relevance	82%	8%

Source: ACTVET student survey data (2022–2024)

6 Discussion

The AI-driven framework demonstrated significant policy impacts, enabling data-driven decisions that redirected AED 2.3 million to address IoT skill gaps and expanded cybersecurity courses by 25 percent. However, scalability challenges emerged, with rural institutions facing infrastructure limitations (40% lacked VR bandwidth) and training gaps. While VR/AR integration showed promise for high-risk training scenarios, cost barriers (AED 12,000 per station) and localization needs delayed implementation. Future directions include cross-cultural adaptation in Germany and India as shown in the figure below, and deeper industry integration through real-time competency mapping with partners like Siemens. Ethical considerations remain paramount, with bias mitigation reducing STEM gender gaps by 18 percent, though socioeconomic disparities persist. The study highlights AI's transformative potential in VET while underscoring the need for equitable implementation strategies and sustainable funding models to ensure broad accessibility.

Figure 7: Proposed Cross-Cultural Adaptation Framework



Source: Authors' elaboration, developed for this ACTVET research; ©ACTVET

Note: This section includes text and image generated with the assistance of OpenAI, GPT-4o Mini (11.03.2025).

7 Conclusion

This study demonstrates AI's transformative potential in VET systems, reducing first-semester dropout rates by 35.7 percent through early warning systems and improving practical assessment scores by 15 to 25 percent via personalized interventions. The framework enabled data-driven policymaking, including strategic reallocation of AED 2.3 million to address critical skill gaps, while ethical safeguards like quarterly bias audits reduced gender disparities in STEM engagement by 18 percent. Although successful in urban Abu Dhabi, scalability challenges emerged in rural areas (40% lacked VR-ready bandwidth), highlighting the need for infrastructure investments. The modular design shows promise for global adaptation, with pilots underway in Germany's dual-system apprenticeships and India's

Skill India Mission, aligning with UNESCO's SDGs for quality education and decent work. Future research should address technological gaps in high-risk training simulations and strengthen industry partnerships through real-time competency mapping. These findings position AI not as a replacement for human-centric pedagogy but as a crucial tool for building responsive, equitable VET systems fit for the Fourth Industrial Revolution.

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Stefan Winnige, Johanna Binnewitt, Kathrin Ehmann, and Kai Krüger

From Job Ads to VET Insights: AI-Based Skill Extraction for Policy and Curriculum Development

Job advertisements provide detailed, cutting-edge insights into employers' skill and qualification requirements and working conditions. Social science research may draw on this new data source to monitor current demand-side developments and to give evidence-based policy advice (e.g., on curriculum reform). However, since job ads are typically presented as plain text with little to no structure, the information of interest must first be extracted. The recent advancements in artificial intelligence tools, such as large language models (LLMs), make extracting meaningful information from tens of millions of job advertisements possible.

In this research report, we share our experience in working with a large corpus of job advertisements. Specifically, we demonstrate how to operationalize concepts, such as skills, provide insights into the annotation process for developing a gold standard, and address pitfalls that may arise during the process.

1 Introduction

Online Job Advertisements (OJAs) serve as a crucial data source for understanding labour market trends, particularly in assessing skill and qualification requirements and working conditions.[1] Social science research can benefit from using job ads to monitor current market developments, and in the domain of vocational education and training (VET), for example, provide evidence-based policy recommendations. However, extracting meaningful insights from job advertisements is not straightforward given their unstructured nature as plain text. Recent advancements in artificial intelligence (AI), particularly large language models (LLMs), provide new opportunities to process and analyze vast quantities of job postings efficiently.

This report addresses the practical and methodological challenges of working with job ads as data. It presents our approach to handling a large corpus of job advertisements, focusing on the operationalization of skill concepts, the development of a gold standard through manual annotation, and key issues in data extraction and analysis. The report is intended for researchers who are beginning to work with job ads, those aiming to refine their

1 During the preparation of this text, ChatGPT (provider: OpenAI, model: GPT-5) was employed as a linguistic and conceptual support tool. The AI was used primarily for phrasing suggestions and for refining individual passages. All content was reviewed, adapted, and integrated independently by the authors. No extended text segments generated by the AI were directly included (April 2025).

methods and make better use of contextual information, and anyone interested in understanding both the potential and the limitations of job ads as a source of labour market data.

2 Information Extraction from Job Advertisements

Job advertisements have been used for various types of analysis in research, such as labour market trends (Arthur 2021), the impact of COVID-19 (Arthur 2021), working from home (Mergener/Winnige 2021, Alipour/Langer/O'Kane 2021), gender discrimination (Chaturvedi/Mahajan/Siddique 2023) and skills intelligence (Verma/Lamsal/Verma 2022). Our work focuses on skill extraction from job advertisements. Examining skills in job advertisements promises new insights into the development of labour demand since, firstly, employers tend to name specific skills, tasks and tools in job ads that surveys rarely cover. Secondly, they often provide rankings of those requirements (must-have vs. nice-to-have), and thirdly, requirements come in contextualized bundles that include related skills, experience, and educational qualification. Combined analyses of this contextual information help to understand how technical developments change tasks – beyond general forecasts of automation. Moreover, additional information on a company's location, sector, and the benefits they offer provide insights on companies' diverse recruiting strategies and how they are connected to structural factors or skills shortages. Currently, there is a huge gap between the discourse that evaluates recent technological developments like AI applications mostly with regard to their potential to fundamentally alter employment and work content (OECD 2019) and the empirical evidence of AI at work (for an overview, see e.g. Giering 2025). Scholars from the sociology of work have criticized such technocentric and technologically deterministic perspectives for their tendency of neglecting work's social and companies' organizational and structural conditions (Howcroft/Taylor 2022; Pfeiffer 2017; Joyce et al. 2023; Wajcman 2006). Therefore, job advertisement data could prove particularly suitable for researching topics like specific applications of digital technology, AI, and their interaction with specific organizational, technical, and social work contexts.

Various methods have been applied to extract information from job ads. These include keyword lists (Stops 2021; Stops et al. 2025), ontology-based approaches (Sibarani et al. 2017), and more recently, transformer-based models (Zhang et al. 2022a; Zhang et al. 2022b; Gnehm et al. 2022). In our work, we also make use of transformer-based models, which extend the aforementioned approaches through fine-grained annotation of concepts and their relations. More details on our approach will be provided in the section on the operationalization of concepts. Before that, however, we aim to raise awareness of the challenges involved in working with OJAs.

3 Opportunities and Challenges in Working with Job Advertisements

3.1 Job ad coverage and representativeness

The main advantages of using OJAs are their accessibility – since they are already in a machine-readable format – near real-time availability, and potential coverage of the job market.[2] In contrast to other countries like Romania, national legislation in Germany does not require employers to publish open positions online (CEDEFOP 2019). Job-Navigator 06/2022 shows that only about two percent of German job ads were published in print media, 57 percent on job portals, 26 percent on the Federal Employment Agency's job portal, eleven percent on company websites and four percent on Xing/Linkedin in 2022 (RE Redaktion 2022). The IAB Job Vacancy Survey 2021 (Kubis 2022) found that, on average, companies used 3.42 recruitment channels to fill open positions.

However, one must keep in mind that there might also be a significant portion of open positions that are not advertised at all and are instead filled through word-of-mouth[3] or other channels. The IAB Job Vacancy Survey shows that in 2021, 53 percent of companies searched for new employees through their own employees or personal contacts, and for 32 percent, this recruitment channel was even crucial to successfully filling the position (Kubis 2022). This may introduce bias into conclusions drawn from labour market analyses based solely on OJAs.

Job ad data can either be scraped online independently or purchased from a vendor. To avoid the time-consuming and error-prone process of scraping, we get our data from Textkernel, a company specified for this task. When compiling individual job ads into a corpus, the main challenge is identifying duplicates, as companies tend to publish their ads across multiple websites to maximize visibility[4]. Textkernel distinguishes between a job and a posting: a job refers to the actual position or role within a company, while a posting is the advertisement of that job – meaning the same job can be posted multiple times, for example, on different platforms or at different times. Deduplication is challenging due to the immense amount of data and the fact that, in some cases, nearly identical postings (e.g., identical except for the place of work) may correspond to distinct jobs, while job postings with considerable textual differences (e.g., due to the required structure of different portals) might still refer to the same job. Table 1 illustrates the relationship between postings and jobs. On average, each job is posted 4.5 to 5.1 times, with the number of postings per job increasing over time. As a result, we typically conduct our analyses at the deduplicated job level.

2 For an overview of the German OJA landscape, see CEDEFOP 2018.

3 Employers use online job portals more for high-skilled positions, while lower-skilled jobs rely on word-of-mouth and the Federal Employment Agency's portal CEDEFOP 2018.

4 This is particularly true for Germany, which has a fragmented online job market with a large number of online job portals CEDEFOP 2019.

Table 1: Number of postings and jobs 2021–2023

Year	Number of postings	Number of jobs	Ratio
2023	78,048,479	15,195,175	5.1
2022	83,233,422	16,736,836	5.0
2021	65,582,691	14,680,559	4.5

Source: own calculations

Another challenge in analyzing job advertisements is the significant presence of ads from employment agencies (see Table 2). These agencies provide services ranging from recruitment and employee leasing to temporary employment. For these types of ads, it is sometimes unclear whether they represent actual open positions or if agencies are merely collecting candidate information for future clients. Additionally, many job postings do not disclose the actual employer, making it difficult to categorize them within the correct economic sector. Thus, we exclude such job offers from industry-specific analyses.

Overall, the coverage of OJAs can be considered as relatively good, particularly given the increasing use of online channels for recruitment. However, it is important to recognize that certain recruitment practices, such as filling vacancies through personal contacts, may introduce biases. Consequently, occupations with a high turnover rate may be overrepresented in OJA data compared to the actual stock of open positions. Additionally, online job advertisements tend to disproportionately reflect jobs requiring medium to high qualification levels (corresponding to ISCO skill levels 3 and 4). To fully understand these dynamics, it is also essential to distinguish between stock data (all currently active postings) and flow data (newly posted ads), as posting durations can vary significantly across sectors and occupations.

Table 2: Number of postings from employment agencies compared to the total number of postings 2021–2023

Year	Number of postings	Number of postings from employment agencies	Share
2023	78,048,479	36,944,248	47.3
2022	83,233,422	40,396,941	48.5
2021	65,582,691	36,583,547	55.8

Source: own calculations

3.2 Job ad contents

A typical job advertisement provides detailed information about the employer, job responsibilities, required skills and qualifications, working conditions and benefits, and the application process. In contrast to printed job ads, online postings are typically not charged based on character or word counts. This gives employers the opportunity to provide this information in greater detail as the inclusion of relevant search terms increases the likelihood of attracting potential candidates (Koopmann-Wischhoff 2020).

However, it is important to recognize that job ads present information selectively – both for brevity and to make the position more appealing to potential applicants. Previous research has shown that job advertisements tend to provide incomplete lists of skills and job contents (Sostero/Fernández-Macías 2021). Especially in Germany, where the vocational education and training system is highly formalized, employers often do not list all necessary skills or tasks explicitly but instead focus on core tasks, specific requirements, and less common or new skills, as simply mentioning an occupational title typically conveys implicit knowledge about the skills and expertise associated with that occupation.[5]

As a result, we do not expect to gain a complete picture of a job, let alone its corresponding occupation, from a single job ad. Instead, we assume that aggregating information from individual job ads at the occupational level results in collective evidence about a particular occupation. For example, we expect ICT occupations to have a higher proportion of job ads mentioning ICT-related tasks, skills, or tools, and within those tools the advanced technologies should be more prominent.[6]

4 From plain text to structured data

Job advertisements are typically presented as plain text, with little to no structured information. Therefore, it is necessary to extract the relevant content in a systematic way. Historically, rule-based approaches (e.g. dictionaries) and statistical models have been used for this task. However, with advancements in deep learning – including models like Long Short-Term Memory Networks (LSTMs) and Transformer-based architectures such as Bidirectional Encoder Representations from Transformers (BERT) and Generative Pretrained Transformers (GPT) – the field has increasingly shifted towards these more powerful methods.

While recent Transformer-based models have generally demonstrated strong performance even in zero-shot settings, where no task-specific training examples are provided, we chose to fine-tune a model in order to maintain greater control over what is classified as a skill or task. Consequently, we labeled (annotated) data not only for training purposes but also to evaluate the model's performance against a gold standard.[7]

4.1 Operationalization of concepts

In order to identify and annotate skills and tasks from job ad texts, these concepts need some formal operationalization. For this purpose, we followed the framework developed by Rodrigues/Fernández-Macías/Sostero 2021, where tasks are defined as discrete units

5 In Germany, formal qualifications, fields of study, the profession and work experience tend to be the main factors driving recruitment decisions (CEDEFOP 2019).

6 For a comprehensive overview of the challenges of working with OJAs, see Müller 2024, Tzimas et al. 2024.

7 Even in the case of a zero-shot model, the results should be evaluated using a gold standard.

of work activity, while skills are understood as the ability to perform those tasks effectively. Each task corresponds to a specific skill, establishing a direct link between tasks and skills. This approach is particularly well-suited for analyzing online job advertisements, as skills are often phrased in terms of experience performing a particular task. Consider the following example:

- Initial experience in maintaining machinery is an advantage.

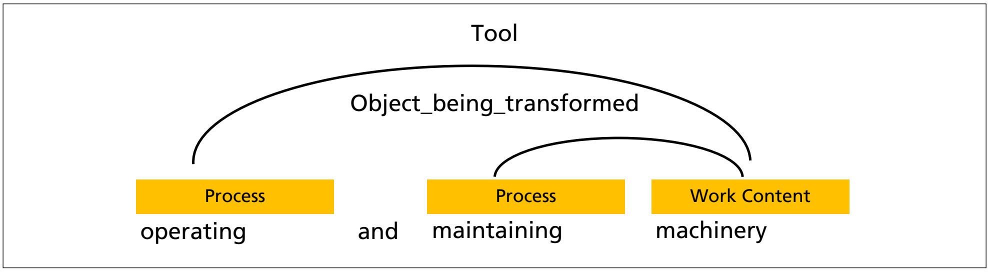
In this example, the task "maintaining machinery" is expressed as a skill by framing it through the experience level "initial experience". In our approach, we further break down the task "maintaining machinery" into two components: "maintaining" (which we refer to as the *process*) and "machinery" (which we refer to as the *work content*). Separating these two components offers several advantages:

1. A single process can be linked to multiple work contents and vice versa.
2. It reduces the extraction of irrelevant information when the process and the work content are not directly adjacent in the text.

To illustrate the first point, consider the example "operating and maintaining machinery". From this, we understand that one must both operate and maintain machinery. In the phrase "operate machinery", machinery functions as a work tool, whereas in "maintain machinery", it is the object being transformed.

This distinction is important if we want to differentiate between what is being done and how it is done. Accordingly, our annotation schema captures this distinction, and a proper annotation of this sentence would look like illustrated in Figure 1.

Figure 1: Example annotation



Source: author's illustration

We call this approach **compositional entity extraction** as it composes higher order concepts like skills from fine-grained entities and their relations. In addition to those concepts mentioned above, we also annotated entities (like *formal qualification*) and relations (like *specialization*). For a complete overview of all entities and relations, see the Appendix.

4.2 Developing a gold standard

The evaluation of our fine-tuned transformer-based models requires some kind of gold-standard, i.e. a dataset of human-annotated job ads. This gold standard data should be created based on transparent and interpersonally comparable rules defined by our annotation guideline. All rules and exemptions that were necessary to annotate job ads in accordance with our operationalization were added to our annotation guideline. After we created a first draft for the guideline, we followed an iterative process to refine it, inspired by the approach described in (Willand/Gius/Reiter 2019). Over six annotation rounds, four annotators (Group A) independently annotated the same five to ten job advertisements. After each round, the annotations were compared using the curation mode of the annotation tool INCEpTION, and the guidelines were refined to improve annotation consistency.[8]

The final annotations of the 500 job advertisements were carried out by 19 researchers from the Federal Institute for Vocational Education and Training (BIBB) (the original four annotators (Group A) along with 15 additional researchers (Group B) from various professional backgrounds). Group B was trained using the final version of the annotation guidelines, video tutorials, and test annotations.

For the test annotations, each member of group B annotated three job ads that were afterwards compared to a gold standard by a member of group A. The member of group B had to achieve a Krippendorff's alpha and Mathet's gamma of at least 0.7. All trainees received a personalized report, and those who did not meet the threshold received additional training from a member of group A.

In order to guarantee high quality of the gold standard data, each of the 500 job advertisements was annotated independently by two annotators (group A & B) and curated by a third person from group A. The curator only had to make decisions in cases where the annotations of the two annotators were inconsistent.

4.3 Training a model

The extraction of entities (like processes or work contents) and their relations (like object-being-transformed or work tool) was done in two steps. The first model focused on entity recognition and classification, while the second model identified the relationships between them. For both steps, we compared four different models (German BERT, German DistilBERT, jobBERT-de, and XLM-RoBERTa). German BERT is a model pre-trained specifically on German text, while German DistilBERT is a lighter, faster version with slightly reduced accuracy. jobBERT-de is fine-tuned on HR and job-related German content, and XLM-RoBERTa is a powerful multilingual model supporting over 100 languages. The best-performing model, XLM-RoBERTa, reached an F1 score of 0.86 for entity extraction and 0.91 for relation classification – indicating high precision and consistency. These results were validated using five-fold cross-validation and tested on unseen data, ensuring

8 The final version of the annotation guideline is available at URL: **https://github.com/TM4VETR/Public_Stea_Annotationsguide** (Retrieved on 08.05.2025). Unfortunately, the guideline is available only in German, as we have annotated job ads exclusively in German.

robustness and generalizability. We found that XLM-RoBERTa could better handle complex or rare cases. Interestingly, some classes with few examples still performed well if they were conceptually clear and errors often occurred in vague or inconsistently defined categories.

Overall, the results show that the proposed method is effective at capturing the rich and complex structure of job ad texts.

5 Exemplary analysis

Despite the growing number of studies on skills in job advertisements, the urgency of skills in recruiting has not received much attention. Skills analyses that merely count the frequency of skills should, however, convey a distorted image of skill demand compared to studies that consider which skills are mandatory and which are optional. Moreover, in a labour market with skill shortages, some employers might, however, consider trading educational requirements (Bone/Ehlinger/Stephany 2024) with skills while others are able to attract qualified applications by means of their location, benefits, or working conditions (Klein/Smith 2024). We used a zero-shot classification model based on mDeBERTa to automatically categorize our extractions according to the apparent importance of each skill.

Each skill or attitude that was linked to an "urgency" relation was sorted into one of three categories:

- Required (e.g., "mandatory", "necessary")
- Preferable (e.g., "desirable", "advantageous")
- Unimportant (e.g., "not required", "not necessary")

Table 3: Frequency of urgency levels

Level of Urgency	Examples	Count
Preferable	desirable, advantageous,…	312
Required	necessary, mandatory,…	127
Unimportant	not necessary, not required,…	27

Source: own calculations

Interestingly, in most cases where a skill or an attitude was mentioned, it was classified as preferable rather than strictly required. Some job ads even explicitly stated that certain skills were not required. This may be because such skills are typically assumed to be necessary for the role, and the employer wants to clarify that they are either not essential or can be acquired on the job.

Without distinguishing between levels of urgency, one might assume that all listed skills are must-haves, which could lead to an overestimation of the actual requirements for the position. Further details about our approach and the training procedure are provided in (Krüger et al. 2025).

6 Next steps

Although we are able to extract information about skills and tasks with relatively high accuracy, the sheer number of distinct terms poses a challenge for further analysis. Many of these terms refer to similar or overlapping concepts, making it impractical to work with them in their raw form. To address this, our next step is to normalize the extracted data by aggregating similar skills and tasks under unified labels.

For this purpose, we aim to align our extracted terms with the ESCO framework (European Skills, Competencies, Qualifications and Occupations), which provides a standardized classification system. To facilitate this mapping, we intend to calculate similarity measures between the textual descriptions of ESCO entities and the terms extracted from our dataset. This will help ensure consistency, reduce redundancy, and enhance the interpretability of our results.

7 Conclusion

This research report highlights the potentials of using online job advertisements (OJAs) as a valuable data source for evidence-based vocational education and training (VET) policy. By leveraging recent advances in natural language processing – particularly transformer-based models like XLM-RoBERTa – we developed a method to extract detailed information on skills and tasks from a large corpus of unstructured job advertisement texts.

Our approach, which combines fine-grained entity extraction with relation modelling, allows us to move beyond simple keyword detection and capture complex, context-sensitive representations of skill requirements. Through the development of a robust annotation guideline and gold standard dataset, we ensured high data quality and model reliability. The strong performance of our trained models demonstrates that this method can be used effectively for large-scale labour market analysis.

Moreover, a first analysis of skill urgency shows how nuanced insights can be gained from this data. Recognizing whether a skill is required, preferable, or unimportant adds significant value to labour market monitoring, CV-to-job matching, and curriculum development.

Nonetheless, certain challenges remain. The high number of distinct expressions for skills and tasks makes normalization and aggregation essential for further analysis. Our next steps will focus on aligning our extracted data with established classification systems such as ESCO, improving comparability, and supporting practical applications in policy and education.

Overall, this work demonstrates that artificial intelligence can unlock the rich information embedded in job advertisements and contribute to more dynamic, timely, and data-driven VET policy development.

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Appendix

List of entities and relations

Entity Type	Description	Example
Attitude	Indicates traits or dispositions desired in candidates.	You are self-motivated
Attribute	Provides additional specifications about other entities.	You design logos for our customer
Experience Level	Refers to prior knowledge or skills required.	Experience in Python
Formal Qualification	Highlights certifications or official qualifications required.	Bachelor's degree in Economics
Industry	Defines the industry or sector associated with the job.	You bring relevant experience in the automotive industry
Occupation	Specifies the role or position advertised.	We are looking for a baker (m/f/d)
Process	Represents actions or sequences required to perform tasks.	You design logos
Work Content	Describes the object, subject, or tool related to a task.	You design logos

Relation Type	Description	Example
Alternative	Denotes alternatives between entities.	Bachelor's degree or minimum of three years of professional experience
Coordination	Connects coordinated morphemes within sentences.	You pre- and post- process texts.
Degree of Autonomy	Specifies the level of autonomy in task execution.	You help your supervisor prepare presentations
Detail	Illustrates subcategories or specifics of an entity.	You are experienced with at least one programming language like Python
Negation	Highlights excluded processes or tasks.	A Bachelor's degree is not necessary
Object Being Transformed (OBT)	Links processes to the items or entities they affect.	You design new logos
Related Entity Parts (REP)	Links separated parts of an entity.	You set the annual budget up
Specialization	Adds specificity to qualifications or roles.	A Bachelor's degree in Economics
Tool	Connects processes to the tools or methods used.	You design Logos using Illustrator
Urgency	Indicates the importance or necessity of an entity.	Experience in Python is mandatory
Zero Relation	Used for connections without specific relations.	You bring experience in programming

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Analytical Review of the State of Affairs in Digital Transformation and the Development of Digital Ecosystems in Vocational and Technical Education in the Republic of Uzbekistan

This article provides an analytical review of digital transformation initiatives and the development of digital ecosystems in technical and vocational education (TVET) in Uzbekistan. It explores policy frameworks, implementation practices, and alignment with international standards, especially WorldSkills. The research underlines challenges in harmonising terminologies and highlights steps taken by the Uzbek government to modernise education through digital platforms.

1 Introduction

This article presents an analytical review of the state of affairs in digital transformation and approaches to the development of digital ecosystems in vocational-technical and secondary specialised education (TVET) in the Republic of Uzbekistan. The relevance of the research is determined by the tasks of creating a unified educational space within the Union State, an integral part of which is digitalisation. Digitalisation serves as both the environment in which vocational education develops and a development vector that defines the content and direction of changes occurring within the educational systems of VET, TVET and secondary specialised education. Education is becoming a sector of the digital economy, an important intangible asset for the state. Changing methods of knowledge transfer impact personal development and identity, leading to the emergence of a new type of learner who independently chooses their development trajectory. The continuous development and improvement of digital technologies, along with their implementation in all spheres of activity, contributes to the formation of digital ecosystems, including in education. While digitalisation and digital transformation in education have already become familiar terms, the concept of a digital ecosystem in the field of education is still in its early stages of development. There is yet to be a stable conceptual framework, as well as established forms and formats for the existence and relationships of participants in digital ecosystems (see UNESCO 2023, p. 44). It is also important to note that the number of publications on this topic is very limited. This analytical review attempts to summarise and compare existing approaches and practices for forming digital ecosystems in vocational education across the countries of Central Asia, with Uzbekistan as a stronghold.

During the digital transformation of regions of Uzbekistan from 2020–2025: it is expected that there will be 78 to 95 percent of the country connected to the internet, including by increasing to 2.5 ports of broadband access, laying 20.000 km of fiber-optic communication lines in entire Uzbekistan and developing a mobile communication network, introducing over 400 digital information systems, e-services and software products in various areas of socio-economic development of regions, training 600,000 people in the basics of computer programming, including the attraction of 1,000,000 young people in the framework of the “One Million Coders” project, information systems and software products for management, production and logistics processes at enterprises of the real sector of the economy. The implementation of over 220 priority projects has led to improvements in the e-government system, accessible via the **https://my.gov.uz** platform (the “Single Portal of Interactive E-Government Services”, launched in 2013).The share of public services provided in electronic format has been increased up to 60 percent by 2023 and is planned to be increased up to 80 percent by the end of 2025, including all sectors of education systems as the next important step (TVET, higher education and etc.) as well as to raise it to 50th place in the e-Government Development Index by 2025.

2 Overview of conceptual framework and digital transformation in education

According to expert assessments, digitalisation in education has undergone several stages from the development of computer literacy to the wide implementation of information and communication technologies (ICT) in the educational process. Despite the fact that the conceptual approaches and terminology in this field are not yet fully developed, both in general and specifically in the system of VET, TVET, and secondary specialised education, the state has already begun discussing and implementing digital transformation, i.e., the application of digital technologies in all educational processes.

The current state of digitalisation in vocational education of Uzbekistan:

- Automation of educational processes through educational management information systems (EMIS – for higher education: **https://hemis.uz/**). The registration of all students in public educational institutions through the web portal has been strictly enforced since the post-pandemic period and after 2020.
- Introduction of digital educational platforms such as E-Maktab (with daily access by parents for schools: **https://kundalik.com/**) and EDU Market (22.12.2025 for schools: **https://edumarket.uz/**) to provide access to various validated educational resources.
- Creation of digital databases for students, teachers, and educational materials (including educational resources in the Uzbek language, multimedia secondary specialised educations, and video courses).
- Monitoring (data management) and logging of the completion of various types of educational activities by participants, including the registration of the learner’s digital footprint (a systematised set of verified digital data on a learner’s academic results),

organising and conducting assessments, and registering the digital footprint of educators (systematised set of verified digital data on the results of a teacher's educational activities – *LMS – Learning Management Systems, HEMIS – Higher education process management information system), Moodle – Modular Object-Oriented Dynamic Learning Environment*), and others.

- Automation of educational processes through educational management information systems (for professional and vocational education: **https://prof.edu.uz/**). The Institute for the development of vocational education is facilitating and supporting the development structure of digital transformation.

The analysis of the terminology indicates a common understanding of the digitalisation process in the Republic of Uzbekistan, with some distinctions from other Asian countries. These differences primarily highlight the specifics of economic development and the regulation of digitalisation and digital transformation processes at the state level. In Uzbekistan, two main approaches to contemporary terminology in the field of digitalisation are traced:

Information and Communication Technologies (ICT) as the first step: within the framework of this approach, special attention is paid to the technological aspect of digitalisation, including the use of various technologies for collecting, processing, storing and transmitting information, as well as the organisation and development of network infrastructures for efficient data exchange. It focuses on the development of digital technologies – such as the internet, mobile applications, cloud services, and other solutions – to improve communication and information processing across various sectors of society, including education, healthcare, the economy and public administration.

Digital transformation as the second step: this approach refers to the broader process of transforming all areas of societal and educational life using digital technologies. It involves not only the introduction of new technologies but also the deep modernisation of processes, services, and behaviour models, affecting digital business, public services, education systems and social structures. Digital transformation implies changes in business processes, the introduction of new management models, improving access to services, and enhancing the quality of life for citizens through digital technologies.

Thus, both approaches cover both technical and strategic aspects of digitalisation, but with different focuses – the first emphasises technology and infrastructure, while the second focuses on their implementation and integration into various areas of public life and the economy. In the global context, digital transformation is understood as "the process of an organization adopting digital technologies, accompanied by the optimization of the system that manages core technological processes" (see Ciancarini 2023, pp. 2–5).

Differences in the interpretation of certain terms have been identified. For instance, in TVET education, the term "digital literacy" places greater emphasis on "the ability to find, evaluate, and clearly convey information using text and other media on various digital platforms" (see Wuttke/Seifried/Niegemann 2020, pp. 2–15).

This term includes "a set of knowledge, skills, and abilities required to live in the modern world, safely and effectively use digital technologies and internet resources, as a result of a comprehensive effort to develop these necessary skills and knowledge, which lays the foundation for increased interest in the field", which aligns more with the current requirements for using information technologies. Overall, the most comprehensive and education-oriented interpretation of the concept of digital ecosystem is a stable system that unites interrelated digital technologies, processes, services and multiple categories of participants, with the goal of creating "value" for its participants. It is important to note that in almost all definitions of a digital ecosystem, the concept of a "digital platform" is used either as the foundation of the ecosystem or as a component of it (see Wuttke/Seifried/Niegemann 2020, pp. 34–64). The identified terminological differences are not of a fundamental nature but lead to the conclusion that there is a need to harmonise the conceptual framework in the field of digital transformation and digital ecosystems in the education sector of the Republic of Uzbekistan. For instance, UNESCO, with EU funding, launched projects to enhance skills in rural areas(see UNESCO 2016, pp. 50–55):

- Modernisation of agriculture and irrigation colleges with updated curricula and teaching methods;
- Focus on gender-responsive qualifications and methodologies to meet labour market demands;
- Alignment with Uzbekistan's National Education Development Strategy (2022–2026).

3 Review of regulatory and strategic documents in the field of digitalisation (digital transformation) in education of TVET

The strategic national priorities for the development of the information society in Uzbekistan set initiatives first and foremost, because of the current youth influx exposed critical gaps in digital infrastructure, particularly in education and public service delivery, prompting the government to accelerate the adoption of e-government systems and online learning platforms. In addition, the stark disparity in education between urban and rural areas has been erased through digitalisation, and include key factors:

- Formation of the information space taking into account the needs of citizens and reliable information;
- Development of the country's information and communication infrastructure;
- Create applications of Uzbek (national language) information and communication technologies, ensuring their competitiveness at the international level (see OECD 2023, pp. 3–7);
- Formation of a new technological foundation for the development of the economy and social sphere.

Strategic priorities include the digital transformation of the education system, ensuring online services for educational organisations implementing programmes for primary general, basic general, secondary general, and vocational education, transitioning services to electronic formats, and integrating them into the Unified Portal of State Services, developing various digital tools and services, and creating conditions for their use in educational organisations, as well as upgrading the qualifications of teaching staff in digital technologies and artificial intelligence. Digitalisation in Uzbekistan began about 10 years ago. In 2012, the Government of the Republic approved the "Comprehensive programme for the Development of the national information and communication system", which was to be implemented from 2013 to 2020.

Table 1: Government Investments in Digital Transformation

No	Initiative	Focus Area	Key Outcomes
1	Digital Uzbekistan 2030	National wide	Over 1,600 projects; full internet coverage in schools and healthcare
2	IT Park Uzbekistan	IT sector development in VET and school levels	Support for startups; establishment of IT Park University and Ministry of higher education, science and innovation
3	Digital Inclusion Project	Rural digital employment	11 Mono centers; 25,000 jobs; training for 6,200 youths
4	Digital Villages Initiative	Rural agriculture innovation	Smart IoT sensors; youth training; DVI hubs in Fergana Valley
5	Skills Development for Employability (UNESCO)	Rural education enhancement	Modernised colleges; gender-responsive curricula; alignment with national strategy
6	UNICEF Giga Initiative	Schools and TVET schools internet connectivity	Nearly all schools connected with at least 10 Mbps bandwidth
7	One Million Uzbek Coders Program	Digital literacy	Over 1.2 million youths trained in programming

Source: Own representation

In 2017, the Government of Uzbekistan approved the "Action strategy for 5 priority areas of development of the Republic of Uzbekistan for 2017–2021"[1]. In 2020, the "Digital Uzbekistan – 2030" strategy[2] was adopted, which plans over 220 priority digital projects, including the improvement of the electronic government system, further development of the domestic software market and information technologies, and the establishment of IT parks in all regions of the country. The priority projects for the educational system aim to:

1 See URL: **https://strategy.uz/index.php?news=1478&lang=en** (Retrieved on 25.04.2025).
2 See URL: **https://lex.uz/ru/docs/7008256?ONDATE=06.10.2020** (Retrieved on 01.05.2025).

- build e-systems and automate management processes for admissions of all types of education (access date: 15.01.2026, **https://uzbmb.uz**);
- increase the number of IT specialists and form mandatory digital competencies in schools, universities, career counseling, and retraining programmes (provided in IT-parks);
- develop and modernise the information and communication infrastructure of the education system and technical base (moodle systems – see for abbreviation in the above);
- form modern electronic educational content and develop digital combined services;
- developing and creating new interactive educational information resources, as well as elements of "e-learning" for all levels of education;
- form a unified information space for the sector (creating an industry-specific state digital platform) and developing electronic services and analytical tools for effective interaction between students, educational institutions, and education management authorities;
- implement services that track student activity, accumulate and analyse data to meet student needs and create personalised "educational trajectories";
- Integrating with state information systems and resources of other government bodies to develop various electronic services using data generated in the education system;
- further improve the technological and information-communication infrastructure of educational institutions. Mentors and Trainers in TVET need specific professional development opportunities in order to increase their ability to use ICT for public learning assessments, individualised instruction, accessing online resources, and to enrich student interaction and collaboration.

Main approved **Key Building Concepts (KBC)** for the future in TVET digitalisation reform system:

1. "Concept of the Development of the Higher Education System of the Republic of Uzbekistan until 2030", approved by the Decree of the President of the Republic of Uzbekistan on October 8, 2019, N°. UP-5847;
2. Creation of "Digital competence centers" by 2020–2026, including high-performance digital equipment classrooms, laboratories, media studios, whose experience will be extended to the entire higher education system of Uzbekistan;
3. Development and implementation of online learning in the MOOC (Massive Open Online Courses) format for students and youths;
4. Recommendations for the structure and content of websites of educational institutions implementing vocational and secondary specialised educational programmes;
5. Implementation of the "E-MINBAR" platform for online lectures, practical sessions, and seminars, as well as their uploading to electronic storage devices, with the use of cloud technologies in educational processes by 2025;
6. The improvement of important information systems for online submission of documents for admission to higher, secondary special, and vocational educational institutions, as well as for student transfers and restorations in state higher education institutions.

The regulatory framework for the digitalisation processes in the Republic of Uzbekistan is outlined in the following documents:

- Law of the Republic of Uzbekistan, dated 11.12.2003, N°. 560-II “On Informatization”;
- Law of the Republic of Uzbekistan, dated 15.04.2022, N°. 764 “On Cybersecurity”;
- Decree of the President of the Republic of Uzbekistan, dated 24.05.2023, N°. UP-76 “On measures for the effective organization of public administration in the field of digital technologies within administrative reforms”;
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4 Integration of modern vocational standards of the WorldSkills standards in educational institutions of Uzbekistan on the basis of Advanced International Experience in the field of technical and professional achievements

Uzbekistan officially joined **WorldSkills International** in recent years, recognising the importance of global skill standards. The initiative has been supported by the **Ministry of Higher Education, Science, and Innovation** and the **Institute for the Development of Vocational Education**. WorldSkills NATIONAL competitions play a vital role in accelerating digital transformation in Uzbekistan by promoting internationally benchmarked skills standards, particularly in technical and digital fields. These competitions encourage the adoption of modern technologies, tools, and methods in vocational education, which aligns directly with the goals of reform case strategy. Through participation in WorldSkills, Uzbek students and instructors are exposed to cutting-edge global practices in areas like IT, me-

3 National database of legislation of the Republic of Uzbekistan see URL: https://lex.uz/en/ (Retrieved on 04.05.2025).

chatronics, automotive technology, and cybersecurity. This exposure drives the modernisation of curricula, infrastructure, and teaching methods in vocational institutions, thereby integrating digital competencies into the national education system.

As an institute for the development of professional education in Uzbekistan, we have chosen about **20** professions from the WorldSkills framework, which have been integrated into our TVET education system. The Ministry of Higher Education, Science, and Innovation of the Republic of Uzbekistan has taken this activity under its control based on a scholarship programme aimed at developing and integrating currently important professional standards into local TVET system. The labour market of the country demands modern curricula such as **Graphic design technology** (*owners of this profession are guaranteed to act as freelancers, business owner or advertising, marketing, design or printing company employee, graphic designer, graphic artist, pre-printing preparatory work, printer, letter picker, font designer, image processing specialist, illustrator, art director, production manager, digital printer, information designer, publisher, brand or packaging specialist*), **Cybersecurity expert** (*owners of this profession are guaranteed to act as cybersecurity analyst and engineer, penetration tester, Information security officer, incident response specialist, security consultant and etc.*). Both curricula have been successfully translated into our local language using the approved template and validated by our team. Step by step, these new skill standards and other crucial WorldSkills professional standards have been introduced in colleges, technical schools, and vocational training centres across Uzbekistan, and developed by our institution as well as implemented in TVET educational organisations. The government has been actively preparing candidates (representatives) to participate in competitions of **WorldSkills Asia** and **WorldSkills International**, fostering skill development at an international level in the future.

5 Conclusion

Uzbekistan is actively forming the legal and methodological framework for the digital transformation of all sectors of the economy, including education. However, specific regulatory and methodological frameworks for vocational education and training (VET) are not yet fully developed and may be the subject of much more separate cooperation projects. Expected outcomes are demand-driven, future-ready VET system capable of producing skilled workers for priority economic sectors (ICT, automotive, green energy, etc.) and a shift in perception of VET, making it a first-choice career path through high-quality, digitally enabled programmes.

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Strengthening Evidence-Based TVET Policy in South Africa: A Data Systems Framework for Enhanced Tracer Data Utilisation

Technical and Vocational Education and Training (TVET) is crucial for South Africa's socio-economic development and addressing unemployment. While the country has valuable data resources like TVETMIS, current systems struggle to effectively track post-training outcomes and graduate trajectories. This gap can be bridged by integrating data science approaches with TVET tracer data, enabling deeper policy insights and better understanding of employment success factors. We propose creating a holistic data ecosystem utilising visualisation, descriptive analytics, and predictive modelling to enhance programme monitoring and forecast outcomes. Our recommendations include implementing interactive dashboards, open data policies, and fostering collaboration between educational institutions, government, and industry. These measures aim to align TVET programmes with labour market needs, promote equity, and address skills development challenges, ultimately creating a more responsive and effective TVET system in South Africa.[1]

1 Introduction

Technical and Vocational Education and Training (TVET) plays a pivotal role in South Africa's economic and social development. It is crucial for addressing skills shortages, promoting inclusive growth, and reducing unemployment, particularly among youth. The South African government has consistently emphasised the importance of TVET in various policy documents, including the National Skills Development Plan (NSDP) and the White Paper for Post-School Education and Training (WPPSET) (Akoojee 2016). These policies stress the requirement for a solid TVET system that can produce graduates who have the skills and competencies the labour market needs. However, the implementation of this vision has faced challenges. While the policy's developmental rhetoric is plausible, the plan's effectiveness is hindered by the lack of a cohesive strategy to integrate TVET with broader economic and industrial policies (Sibiya 2023; 2025).

A significant gap exists in South Africa regarding comprehensive data on TVET graduate outcomes. Although the Technical and Vocational Education and Training Management Information System (TVETMIS) provides important administrative information, its usefulness is limited when trying to track graduates' employment paths in the long term and the effect of their training on their careers. For instance, systems often struggle to track graduates who move between industries, switch careers, or pursue further education, leading to

1 This abstract was shortened using Google, Gemini Pro 2.5, July 2025.

incomplete or outdated information (LETA et al. 2024). Furthermore, the fact that different institutions and areas do not collect data in the same way only worsens this problem, leading to information that is scattered and inconsistent. The lack of consistent data makes it much harder for those in charge to make smart choices about where money should go and what kind of help TVET graduates and the job market really need. Without a clear picture painted by reliable data, policymakers are left guessing, which can lead to wasted resources and programmes that don't truly hit the mark.

Longitudinal tracer studies such as the 2016 research by the Swiss-South African Cooperation Initiative (SSACI), JET Education Services (JET), and the National Business Initiative (NBI) into TVET college graduate transitions (SSACI/JET/NBI 2016) offer a crucial, yet arguably underutilised, data resource to bridge this gap. These studies track graduates over time, providing insights into their employment status, earnings, career progression, and the relevance of their training. However, the full potential of tracer data has not been realised in South Africa. Traditional analysis methods are often insufficient for extracting meaningful insights from these rich datasets due to several key constraints including the high costs associated with data collection and processing, limited accessibility of raw data for secondary analysis, and methodological challenges in handling complex longitudinal information at scale.

Traditional analytical methods, often reliant on aggregate statistics and basic cross-tabulations, can struggle to unearth the deeper, multi-dimensional trends and causal inferences hidden within the rich, individual-level datasets these tracer studies produce. This is where data science offers a transformative lens. This paper argues that data science offers a powerful set of tools and techniques to unlock the potential of TVET tracer data. By applying data science methods, it is possible to gain a deeper understanding of graduate outcomes, identify factors influencing their success, and inform evidence-based policies that enhance the effectiveness of the TVET system. This paper illustrates this potential and suggests practical directions for leveraging data science in TVET policy, drawing on the tracer studies conducted by the Department of Higher Education and Training (DHET), the work of SSACI, JET and the NBI on graduate transitions, and international best practices in data utilisation for TVET (World Bank/UNESCO/ILO 2023) to illustrate how data science can amplify the policy relevance of such work).

2 Context: The Need for Evidence-Based TVET Policy in South Africa and the Role of Tracer Studies

As a key component of South Africa's economic development and skills training plan, TVET plays a special role in developing a workforce that meets the demands of industry. A number of Department of Higher Education and Training (DHET) strategies, for instance, the White Paper on Post-School Education and Training (WPPSET) and the National Skills Development Plan (NSDP) incorporate the government's emphasis on TVET as an essential part of national development (DHET 2019; 2023). Equitable access to vocational training, improved industrial relationships, and a smooth transition for graduates into the workforce are the goals of these policies. The effectiveness of TVET in accomplishing these goals is, however, limited by existing data challenges, particularly in monitoring graduate labour market outcomes.

The fragmentation of data systems, where enrolment and completion numbers are available but thorough graduate employment monitoring is insufficient, is one of the most significant constraints in South Africa's TVET sector (DHET 2019). Policymakers' capacity to assess long-term employment trajectories, career advancement, and skills relevance in the labour market is limited by traditional administrative statistics, which concentrate on institutional performance rather than graduate-centric data (Rivera et al. 2022). In the absence of linked datasets, policymakers find it difficult to create policies that guarantee graduates have applicable and flexible skills for changing industries (Kis 2020). Consequently, despite their occupational credentials, TVET graduates frequently encounter skills mismatches, which raises unemployment rates (Macginty 2024).

In order to address this gap, tracer studies offer longitudinal perspectives on the employment paths of graduates, providing vital data on career advancement, labour market integration, and the relevance of skills. By highlighting graduate trajectories beyond immediate post-training employment, these studies show how vocational qualifications affect employer satisfaction, career stability, and salary development. Tracer studies, as opposed to static institutional records, monitor workforce entry over time, providing a more thorough assessment of TVET effectiveness (DHET 2023).

Tracer studies conducted in South Africa, particularly the one by SSACI, JET, and the NBI in 2016, have aimed to evaluate the outcomes of National Certificate (Vocational) (NC[V]) students. This 2016 study followed up with 9,000 students to assess their experiences and employment status post-training. These studies showed that employment outcomes from TVET programmes are disappointing, with high unemployment rates among TVET completers. Furthermore, while a substantial percentage of TVET completers were studying further (e.g., 14%, 27%, and 17% across different comparator studies including Mashongoane 2019, and Papier et al. 2019), tracer studies could provide a basis for data science to explore why this was so. Was studying further a response to the perceived low value of the NC(V) in the labour market, a desire for academic progression, or the pursuit of a pathway to a different career field? Understanding these nuances through more advanced analytics is crucial for policy development. Furthermore, specific skills mismatches or challenges in workplace entry highlighted in these studies could be dissected more effectively with the use of data science.

Integrating data science approaches into the TVET sector presents an opportunity for innovative, evidence-based policymaking, especially considering the shortcomings of current data management systems. Big data integration, machine learning, and predictive analytics can improve the usefulness of tracer studies and improve policy design by following the labour market in real time (HAQUE et al. 2024). South Africa can better match TVET programmes with the needs of the labour market by utilising these strategies, guaranteeing that vocational training stays impact-driven, relevant, and responsive (Nirmalkar/Sahu 2025). The need to improve tracer study analysis using data science methods serves as the basis for the following section, which examines real-world uses of artificial intelligence (AI)-driven insights in TVET governance.

South Africa's TVETMIS system lacks the integration of real-time data, making it difficult to track students' progress and employment transitions (DHET 2023). Employers play a minimal role in shaping TVET curricula, leading to gaps in practical, job-relevant skills for the labour market (Rivera et al. 2022). Moreover, TVET graduates frequently have challenges finding work since their skills do not match labour market demands (Macginty 2024). Just 38 percent of TVET graduates find work within six months after graduation, according to a 2019 study by Akoojee et al. This resonates with earlier findings from the SSACI/JET/NBI 2016 study, which indicated significant hurdles exist for graduates in securing sustainable employment, pointing to systemic issues that require more than just broad-based enrolment and completion targets.

Table 1: Key Challenges in South African TVET Data Systems, Policy Design Impact, and Data Science Solutions

Challenge	Impact on Policy Design	Data Science Solution
Data fragmentation and silos (TVETMIS limitations)	Inability to assess long-term employment trajectories and programme effectiveness	Integrated interactive dashboards for holistic views
Insufficient long-term graduate outcome monitoring	Difficulty in linking specific training interventions to graduate success	Longitudinal tracer studies enhanced by data science
Inconsistent data collection standards	Evidence-based resource allocation and targeted support hindered	Standardised data definitions and formats across all institutions
Limited employer involvement in curriculum shaping	TVET curricula not aligned with dynamic industry needs	Predictive analytics for skill forecasting and curriculum alignment
Skill mismatches and high graduate unemployment	Wasted resources, perpetuating youth unemployment	Advanced descriptive analytics for performance and equity monitoring
Lack of real-time labour market insights	Reactive rather than proactive policy development	Real-time data integration for agile policy responses
Underutilisation of existing tracer data	Missed opportunities for deep, actionable understandings from valuable data	Advanced visualisation and predictive modelling to unlock latent value
Outdated facilities and lack of practical experience	Graduates lacking work readiness despite qualifications	Data-driven insights to promote work-integrated learning and industry partnerships

Source: Compiled by the authors, synthesised from key South African TVET tracer studies, Rogan/Papier 2020; SSACI/JET/NBI 2016; Rogan et al. 2024

3 Illustrating the Potential: Conceptual Data Science Framework for TVET Tracer Data

Data science provides a powerful lens through which to analyse TVET tracer data, moving beyond problem identification to offer concrete solutions. A conceptual framework demonstrates how tracer data can be transformed into actionable policy recommendations through data visualisation, descriptive analytics, and predictive modelling.

3.1 Modern Data Visualisation for Policy Insights

Interactive dashboards can facilitate the transformation of complex tracer data into easily understandable and actionable insights by providing policymakers with a dynamic view of graduate outcomes which facilitates the exploration of different dimensions of the data and identification of key trends.

A dashboard can be designed that visualises employment rates by programme type and region. Policymakers can identify successful programmes and high-demand regions and drill down by demographic group or qualification level. This improves communication and analysis, enabling a quick grasp of key findings for informed decisions (Williamson 2014). Moreover, a dashboard reflecting low employment rates for a specific programme in a particular region can act as an early warning system, prompting investigation and targeted interventions. Such policy-centric dashboards, focusing on key performance indicators (KPIs), become active policy management tools, enabling continuous improvement cycles.

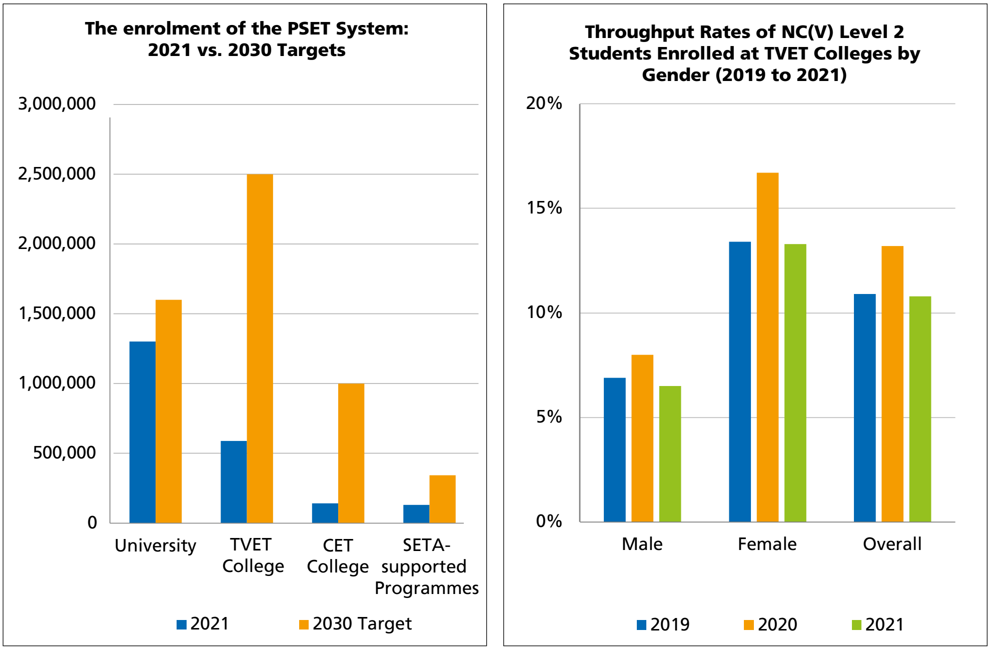
The National Pathway Management Network (NPMN) dashboard, developed and administered under South Africa's Presidential Youth Employment Initiative (PYEI), exemplifies the effective use of data visualisation (DHET 2019; Paterson et al. 2025). The NPMN dashboard transforms complex programme data into an easy-to-understand visual format, empowering stakeholders to evaluate performance and pinpoint areas needing attention. This clear presentation fosters well-informed decisions and improves communication between educators and policymakers, leading to a better grasp of patterns and results. As a central hub for monitoring performance, the dashboard is crucial for tracking progress (Paterson et al. 2025) and implementing data-backed solutions. By systematically assessing educational programmes, the dashboard helps refine strategies and optimise resource use, ultimately boosting student learning. In essence, the NPMN dashboard exemplifies how data visualisation can drive significant educational advancements).

3.2 Advanced Descriptive Analytics for Performance and Equity Monitoring

Descriptive statistics and cohort analysis can be used to monitor programme performance and equity. By tracking key metrics such as enrolment, employment/earning rates, and throughput rates over time by demographics, it is possible to identify trends and patterns that can inform policy decisions (NSFAS 2016; Rogan/Papier 2020).

Figure 1 shows an example of how descriptive analytics can be used to track enrolment targets and throughput rates. Figure 1 (left) reveals a strategic direction within the PSET system to significantly increase enrolment in TVET Colleges and CET Colleges by 2030, with a more modest growth projected for Universities and SETA-supported programmes. This suggests a national priority should be strengthening both the policy framework and the underlying data infrastructure to support this expansion effectively and ensure the delivery of high-quality TVET.

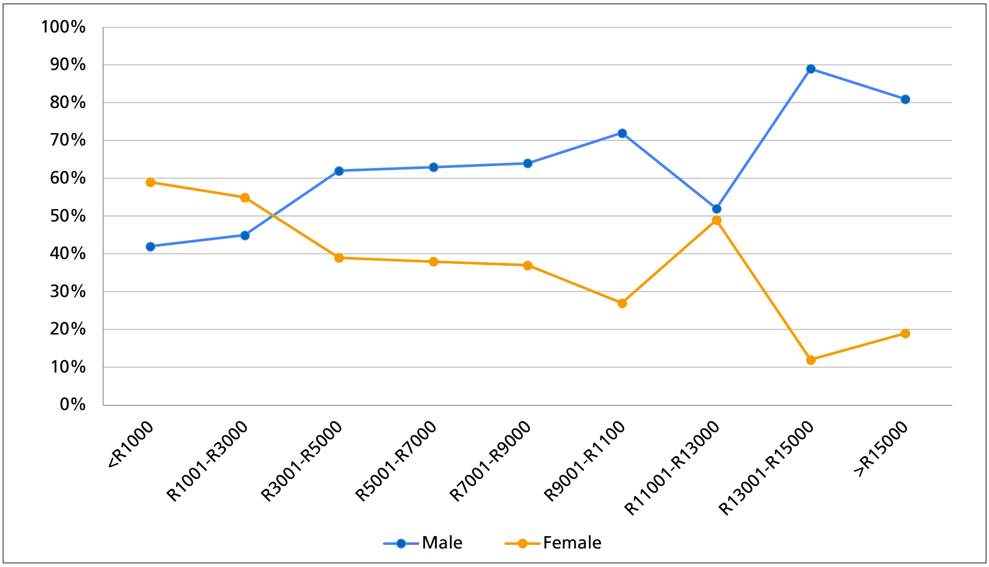
Figure 1: Enrolment 2021 vs 2030 Targets (left) Throughput rates by gender (right)



Source: Own creation based on Statistics on Post-School Education and Training in South Africa; Throughput rate of TVET college NC(V) (National Certificate Vocational) students (DHET 2024)

Figure 1 (right) highlights a concerningly low throughput rate for NC(V) Level 2 students at TVET Colleges, with a notable and persistent gap between male and female student success. While there was a general improvement in 2020, the rates declined again in 2021.

Figure 2: Earning distribution by gender



Source: Own creation based on Tracer Study of the Transition of Students from TVET Colleges to the Labour Market, South Africa (SSACI/JET/NBI 2016)

Figure 2 clearly indicates a gender disparity in earning distribution. A higher proportion of women tend to be concentrated in the lower income brackets, while men become increasingly dominant in the middle and especially the upper income brackets. This is corroborated by ROGAN et al. (2024) who found women TVET completers still face significant discrimination in the labour market, earning around 22 percent less than men, in addition to experiencing lower employment rates. These disparities indicate systemic gender inequality. Descriptive analytics can – and should – incorporate intersectional analysis (e.g., gender by programme type, region, socio-economic background) to uncover nuanced inequality patterns for effective, equitable interventions.

3.3 Leveraging Predictive Modelling for Targeted Interventions

Predictive modelling offers a powerful toolkit for identifying factors influencing graduate employment. Models can explore impacts of prior education, programme type, demographics, and economic conditions. Model outputs indicate each factor's predictive strength. Interpretability is crucial; understanding success factors allows policymakers to design targeted interventions. For instance, if a model reveals that graduates with prior work experience are more likely to be employed, policymakers could actively promote work-integrated learning opportunities within TVET programmes.

Predictive analytics in education and labour market outcomes encompass diverse applications including forecasting student performance and identifying at-risk students for early intervention to prevent absenteeism or dropout. These methods also enable the personalisation of learning experiences by understanding individual student learning styles and tailoring teaching strategies accordingly. Furthermore, predictive models can be utilised to predict TVET courses based on personality traits, demographics (age, gender), and examination scores, thereby informing career guidance and programme placement. Beyond academic settings, predictive analytics are crucial for evaluating programme effectiveness based on employment outcomes, wage growth, skill development, career progression, and industry demand. Lastly, these approaches are vital for predicting employee retention and attrition and optimising talent acquisition processes in human resources, providing a robust model for understanding graduate career stability.

To facilitate the development of such powerful predictive models, specific data requirements must be met. Table 2 below outlines these essential data categories and their relevance.

Table 2: Data Requirements for Effective Predictive Modelling with TVET Tracer Studies

Data Category	Relevance for Predictive Modelling
Student Demographics (Age, Gender, Race/Ethnicity, Socio-economic status, Geographic location)	Identifies at-risk groups, informs equity-focused interventions, predicts programme choice
Prior Educational Background (Previous qualifications, Academic performance prior to TVET, Prior work experience)	Predicts success based on foundational knowledge, informs admissions criteria and targeted support
Programme-Specific Data (Programme type/field of study, Duration of study, Enrolment/Completion dates, Throughput rates, Attendance records, Assessment scores)	Assesses programme effectiveness, identifies high-performing programmes, predicts completion
Engagement and Support Data (Participation in extracurricular activities, Utilisation of student support services, Participation in internships/work-integrated learning)	Predicts retention/dropout, informs targeted support mechanisms
Post-Graduation Outcomes (Tracer Data) (Employment status, Job placement/retention rates, Earnings/Wage growth, Career progression, Indus-try/Sector of employment, Perceived relevance of training, Employer satisfaction)	Predicts employability, earnings potential, and long-term career trajectory; measures programme impact
Labour Market Indicators (Regional industry demand for specific skills, Economic conditions, Occupational forecasts)	Informs curriculum alignment, forecasts future skill needs for proactive programme adjustment
Qualitative Data (Student feedback/satisfaction surveys, Alumni interviews, Employer feedback on skill gaps)	Provides rich context for quantitative findings, identifies non-quantifiable factors influencing success

Source: Compiled by the authors, synthesised from key South African TVET tracer studies: Rogan/Papier 2020; SSACI/JET/NBI 2016; Rogan et al. 2024

It is crucial to acknowledge, however, that the comprehensive, linked datasets required for robust predictive modelling are largely unavailable within the current South African TVET data ecosystem, beyond the limited scope of a few existing tracer studies (World Bank et al. 2023). The challenge lies not merely in the absence of individual data points but in the lack of interconnected and longitudinal data that would allow for a holistic understanding of student trajectories and labour market outcomes. This fragmentation of variable data significantly hinders the ability to apply advanced predictive techniques. As noted above, the findings from Rogan et al. (2024) demonstrate a stark earnings disparity between male and female TVET graduates. Despite the consistently higher throughput of female students, this gender gap persists. Further investigation into the factors contributing to these differences at both student and graduate levels could reveal ways to address this inequality but this requires enhancements to TVET data systems to enable more comprehensive tracking, analysis, and reporting of student performance and graduate outcomes.

4 Policy Implications and Practical Directions

As argued above, the application of data science methodologies in the TVET sector holds profound implications for policy formulation and practical implementation, enabling a shift towards a more responsive and effective system.

4.1 Curriculum Alignment and Skill Development

Predictive analytics, leveraging machine learning models to forecast student outcomes and labour market trends, can directly inform targeted curriculum modifications within TVET programmes. This capability allows TVET institutions to proactively adapt their offerings to evolving industry demands, moving beyond static or periodic adjustments to embrace a dynamic, continuously responsive curriculum. Given the rapid pace of technological advancements and shifting industry demands, a model updated by real-time labour market data feeds and predictive modelling becomes imperative.

Furthermore, the implementation of AI-powered learning management systems can significantly enhance student success rates. These systems can analyse student performance data, pinpoint early warning signs for potential dropout concerns, and provide tailored interventions, thereby improving retention and completion.

4.2 Promoting Gender Equity in TVET Outcomes

The stark gender disparity in earning distribution, where a higher proportion of women are concentrated in lower income brackets while men dominate higher ones, underscores an urgent need for comprehensive policies addressing the gender pay gap. This persistent gap is a strong indicator of systemic discrimination and deeply entrenched occupational segregation within the South African labour market.

Policy interventions must therefore move beyond merely promoting enrolment and actively address the underlying structural biases and societal norms that may steer women away from higher-paying, often male-dominated, fields, perpetuating unequal pay and limited career progression post-training. Such policies could encompass equal pay legislation, active promotion of gender equality in the workplace, targeted measures to tackle occupational segregation, robust support systems for working mothers, and initiatives to ensure salary transparency. TVET policies should specifically focus on guiding female students towards high-demand, high-earning fields and fostering collaboration with employers on equitable hiring practices. A multi-pronged policy approach is required, combining data-driven insights (identifying specific programmes or sectors where gender disparities are most pronounced) with active legislative and programmatic interventions. This could include reforming career guidance within TVET to challenge gender stereotypes, incentivising industries to promote equitable hiring and promotion practices, supporting women's entrepreneurship, and implementing robust monitoring mechanisms for gender-disaggregated labour market outcomes to track policy effectiveness. These moves align with the broader objective of fostering economic well-being beyond just job attainment, ensuring dignified work and equitable opportunities for all TVET graduates

4.3 Fostering Collaboration and Open Data Ecosystems

Enhanced collaboration among educational institutions, government agencies, and industry stakeholders is paramount to ensure that TVET programmes are dynamically aligned with current and future labour market needs. Strong partnerships characterised by a shared vision, complementary skills, joint leadership, and clearly defined roles and responsibilities can empower TVET colleges to remain responsive to new technologies and practices across various occupations and fields, thereby maintaining their relevance in an era of rapid technological, social, and economic change (Njengele et al. 2024)). Industry partners should be actively involved across various stages of TVET provision including planning activities, student selection, facility preparation, teacher development, and the creation of teaching materials (Njengele et al. 2024). Developing and enhancing partnerships with prospective TVET employers is crucial for addressing challenges such as the persistent shortage of placements for work-integrated learning.

This emphasis on collaboration extends beyond curriculum alignment; it is a fundamental prerequisite for building and sustaining robust TVET data systems. Active industry involvement ensures that the data collected is relevant to employers' needs and directly informs skill requirements. Government coordination, in turn, ensures data standardisation, interoperability, and sharing of facilities across the ecosystem. This collaborative approach to data generation, collection, and utilisation creates a continuous feedback loop that acts as an inherent quality assurance mechanism for TVET programmes and policies. Collaboration is not just about programme design but about co-creating and utilising a shared, dynamic data ecosystem that feeds back into programme improvement, policy refinement, and ultimately, enhanced graduate employability, ensuring the TVET system remains agile and responsive.

Table 3: Best Practices for TVET-Industry-Government Collaboration in South Africa

Best Practice Area	Specific Actions/Mechanisms
Shared Vision and Goals	Develop joint vision/mission statements; define common projects and shared interests
Industry Involvement in Curriculum	Industry participation in curriculum design, student selection, teacher development, and provision of teaching materials
Data Sharing and Standardisation	Establish standardised data definitions and formats across all entities; formalize data sharing agreements
Joint Leadership and Governance	Form joint committees/advisory boards; define clear roles and responsibilities; foster shared contributions and joint leadership
Continuous Feedback and Adaptation	Implement regular feedback loops on graduate performance, industry needs, and labour market trends

Source: Own elaboration by authors

The implementation of open data policies is equally vital for fostering transparency and innovation within the TVET sector. By allowing stakeholders, including researchers and the public, to access relevant TVET data, these policies encourage broader collaboration and innovation in analysing TVET outcomes. South Africa's national policy on data and the cloud explicitly supports such transparency, stating that Government must develop an Open Data Framework that enables everyone to access government data whilst still being compliant with existing data protection policies and legislation (DCDT 2024, pp. 23). The availability of publicly accessible anonymised, aggregated, open TVET data, that nonetheless adheres rigorously to privacy legislation like the Protection of Private Information Act, 4 of 2013, can act as a powerful catalyst for external innovation. Researchers, data scientists, start-ups, and civil society organisations can leverage this data to develop novel analytical tools, dashboards, and insights that government or individual institutions might not have the internal capacity or resources to create. Open data policies, while requiring careful consideration of data privacy and security, are crucial for fostering a broader ecosystem of data-driven innovation and external scrutiny, ultimately leading to a more robust, effective, and publicly accountable TVET system.

5 Conclusion

The paper motivates for transforming TVET policy in South Africa through a modernised data framework. The deployment of data science in the TVET sector represents more than a mere technical upgrade; it signifies a fundamental paradigm shift towards a more responsive, equitable, and ultimately more effective education and training system.

When fully integrated and leveraged, data science can drive systemic transformation within the entire TVET ecosystem, moving beyond incremental optimisation to fundamentally reshaping how policy is conceived and implemented, how curricula are designed and adapted, how students are supported throughout their learning journey, and how the TVET system interacts dynamically with the labour market. This represents a crucial transition from a reactive approach to a proactive, integrated, and continuously learning system, essential for building a truly adaptive, equitable, and impactful TVET system capable of responding effectively to South Africa's complex and evolving development needs and fostering a future where vocational education genuinely empowers citizens.

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Mario Steiner

How Socially Selective is the Vocational Education System in Austria? New Insights from Analysing Register Data

The recent opening of register data strongly increases opportunities for (educational) research in Austria. This article presents the general data-framework and introduces a concrete register-based longitudinal data set on educational and occupational trajectories for a complete cohort of school entrants. Following this, a practical application of analysing this data is discussed. Analyses will focus on the research question of how socially selective educational trajectories in upper secondary education are. To serve this topic, the social structure of various forms of vocational education as well as academic secondary school according to gender, migration background and parents' education are compared. In addition, the question of how social structure develops by comparing population upon entry, upon dropping out, and upon graduation is discussed. This allows us to answer the question whether the widely known social selectivity of school-choice is enforced during its attendance and how this is shaped by sociodemographic characteristics. Empirical results lead to conclusions on counteracting policy measures that are needed.

1 General introduction to register-based research and to a specific data set on educational and occupational careers

Since 2022, changes in law made it possible to widely access administrative microdata for research purposes in Austria.[1] The number of accessible registers and microdata sets is constantly increasing and currently comprises 143 data sets, all of which can be linked at the individual and/or institutional level using unique identifiers (e.g. the bPK – sector-specific personal identification number). Data protection is ensured through encryption by the independent "Master-Data-Register-Authority" (Stammzahlenregisterbehörde), which is the only institution with access to information on the identity of individuals. These data are made available via remote access by Statistics Austria upon request using the "AMDC-Austrian Micro-Data-Center"[2].

In this article, I use a register data set covering the school entry cohort of 2006/2007 with 83,465 individuals to analyse the research question of social selectivity at entry to

1 DeepL was used for an initial translation of the manuscript and further revising (August 2025).

2 URL: **https://www.statistik.at/en/services/tools/services/center-for-science/austrian-micro-data-center-amdc** (Retrieved on 29.05.2025).

upper secondary education as well as its development throughout the different forms of education. The variables in this AMDC-data-set provided by Statistics Austria are widely dispersed and originate from a wide variety of registers, among them school- as well as higher education statistics, the (highest) education register, labour market statistics, the population register and many others. Concerning content, the data set includes information on individuals (gender, migration background) and their origins (e.g. parents' education, employment, labour market status, and income) as well as information on educational and professional careers (career information covering 16 years on types of schools attended, labour market status, and employment characteristics). In addition, the data set contains information on social structure of the educational institutions attended (proportion of parents with certain educational levels and labour market status as well as migration background).

The subgroups considered in this article comprise beginners in certain forms of education, dropouts from it and graduates. To operationalise the beginners, all those who started a type of school in their ninth or tenth school year (in the case of apprenticeships, the 10^{th} or 11^{th} school year) were selected. Graduates are defined as those whose highest educational status equals this type of school or even higher. Those people starting a form of education but not reaching a degree on this level are considered dropouts. Analyses cover subgroups of the cohort in apprenticeship (dual training), School for Intermediate Vocational Education (BMS/Berufsbildende mittlere Schulen), College for Higher Vocational Education (BHS/Berufsbildende Höhere Schulen) and Academic Secondary School (AHS or Gymnasium/Allgemeinbildende Höhere Schulen). Analyses of social structure will focus on the share of females, students with migration background, students with parents having a low and high level of education.

2 Social differences in educational trajectories through upper secondary school types

The analytical section of the register data presented before is devoted to the research question how socially selective entry into and progression through upper secondary education is in comparison of different forms, respectively types of general and vocational education. Register data allows us to analyse this question in a longitudinal perspective instead of a only cross-sectional one (see Steiner 2023). Social selectivity refers to differences in gender, migration background and parental education (parents with low and high level of education). In a first analytical step, the social structure of beginners in the different educational forms considered is compared to the social structure of the entire cohort. This shows selectivity at the entrance-level. In a second step, the social structure of beginners will be compared to the social composition of dropouts and graduates. This makes it possible to answer the question of whether the social selectivity of entering different school types at upper secondary level is complemented by comparable socially unequal dropout- and graduation-selectivity, either reducing or even increasing selectivity at large. Comparing different forms of vocational and general education will also show whether selectivity varies and develops differently according to trajectories and concerning socio-demographic characteristics.

Based on sociological theory, major social differences are to be expected here. Boudon (1974), for example, points out that primary and secondary background effects contribute to social inequality. Primary background effects result in differences in competence and performance between children with different resource-levels during the socialisation process. Children from educationally disadvantaged families often do not receive parental support in learning, which is reflected in lower average competence levels and vice versa. The secondary background effect causes disadvantaged children more likely to not choose (higher) school types even if they have sufficient or above-average competence levels. This is because in a cost-benefit-analysis, they systematically overestimate the costs and systematically underestimate the benefits of (different forms of) education. In addition, opportunity costs also vary significantly according to social background. Quite simply, longer education (instead of contributing to family income) must also be affordable. Bourdieu/Passeron (1971), on the other hand, cite cultural capital as a decisive resource for the course of educational careers. Depending on their social background, students have different levels and forms of cultural capital, which is rewarded to varying degrees in the education system or can even become a disadvantage. In order to reproduce existing structures and hierarchies, the cultural capital of (educational) elites is assumed and rewarded in the education system, while that of disadvantaged groups is filtered out. This is why Bourdieu and Passeron conclude that equal opportunities remain an illusion. Both theoretical approaches suggest that the choice of educational forms and pathways as well as the (successful) completion of them are highly unequally distributed across social groups.

Looking at the analysis results in Table 1, the assumptions on social inequality are confirmed: women, who make up 48.7 percent of the entire cohort, are significantly underrepresented (33.8 percent) among the beginners of an apprenticeship but are overrepresented in all other types of vocational schools. In AHS, they even reach a share of 57.5 percent, which is 8.8 percentage-points above their share in the entire cohort. Young people with a migrant background are slightly underrepresented when entering the dual system and BHS, but not in BMS or in AHS.

Table 1: Proportions of socioeconomic sub-groups in cohorts and stages of training (in %)

	Group	Cohort	Apprenticeship	BMS	BHS	AHS
Beginners	Female	48.7	33.8	52.6	51.6	57.5
	With a migrant background	34.0	29.1	34.0	29.7	33.2
	Parents with low education	9.6	11.6	11.1	6.0	4.4
	Parents with higher education	38.8	16.0	20.0	43.1	67.3
Dropouts	Female	48.7	27.6	43.0	42.8	47.1
	With a migrant background	34.0	46.6	58.2	39.8	43.5
	Parents with low education	9.6	21.8	21.6	9.9	8.1
	Parents with high education	38.8	14.3	21.1	32.4	47.1
Graduates	Female	48.7	34.9	54.1	55.3	59.6
	With a migrant background	34.0	25.9	30.1	25.5	31.2
	Parents with low schooling	9.6	9.8	9.4	4.4	3.6
	Parents with high education	38.8	16.3	19.8	47.5	71.2

Note: BMS/Berufsbildende mittlere Schulen: Schools for Intermediate Vocational Education; BHS/Berufsbildende Höhere Schulen: Colleges for Higher Vocational Education/Academic Secondary School; AHS or Gymnasium/Allgemeinbildende Höhere Schulen: Academic Secondary School

Source: Own representation based on Statistics Austria/AMDC-register-data, N=83,465

The clearest picture of social inequality emerges according to parental education. If parents have at most a compulsory school-leaving certificate, which equals low degree of education, their children are overrepresented when entering apprenticeships and BMS. This – at a first glance – can be interpreted as a starting point for curbing inheritance of low educational attainment. However, the persistent social selectivity is evident by looking at the significantly below-average proportions of students with poorly educated parents entering higher secondary education (BHS, AHS). Only 4.4 percent of AHS-entrants originate from lowly educated households, while their share of the cohort is 9.6 percent. This means that disadvantaged students are underrepresented by more than half. If the parents have a higher level of education (a high school diploma or even higher), the picture reverses. These young people are clearly underrepresented in apprenticeships and BMS (the lower forms of education) by more than half, while they are almost overrepresented twice in general academic schools.

So, upon entry into upper secondary education, students' social structure varies heavily when comparing different educational forms. The second part of the analysis now examines social selectivity across the different educational pathways chosen (apprenticeship, BMS, BHS, AHS). Social selectivity is assessed by comparing the proportions of specific subgroups – females, individuals with a migration background, and learners with low- or high-educated parents – among entrants, dropouts, and graduates.

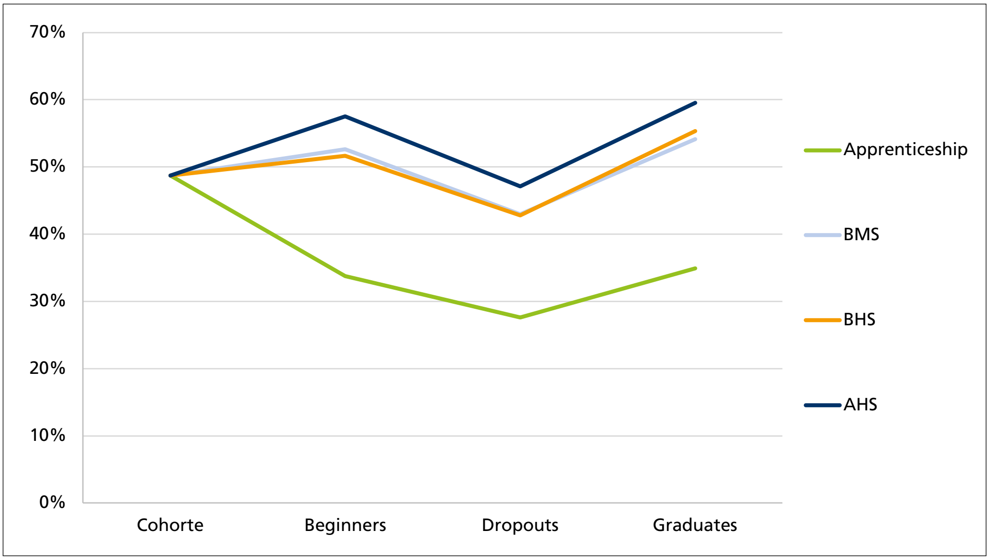
This will allow us to conclude if socially selective dynamics decrease or even increase over the course of training.

When broken down by gender, all forms of training show a lower dropout rate among women, which, in turn, causes, compared to the initial proportions among beginners, the proportion of women among graduates to rise. For example, the already high proportion of women in grammar schools rises from 57.6 percent at the start to 59.6 percent among graduates due to their low share among dropouts. On the other hand, concerning migration background, a previous analysis showed comparatively low entry-selectivity in some forms of education and training. However, a significantly above-average dropout rate leads to the fact that selectivity based on migration background is more pronounced among graduates. For example, the proportion of students with migration background among BMS entrants corresponds exactly to their share in the cohort of 34 percent but falls to 30.1 percent among graduates due to a high dropout-rate among this group. In the same course, their proportion of 29.4 percent among BHS beginners, which is already almost 5 percentage-points lower than in the overall cohort, falls to 25.5 percent among graduates.

However, the highest selectivity is evident in relation to the educational level of parents. If parents' education is low, which applies to around ten percent of the cohort, this is associated with noticeably lower entry rates into higher forms of education in upper secondary education. An above-average dropout rate subsequently leads to a further significant reduction in these already low shares. Among BHS graduates, their share is only 4.4 percent, and among AHS graduates, it is even lower at 3.6 percent, resulting in an underrepresentation of almost two-thirds. The situation is "similar" for students with highly educated parents, but with the opposite sign. A lower dropout rate in higher school types rises e. g. their share among AHS graduates to 71.2 percent – almost double their share in the overall cohort.

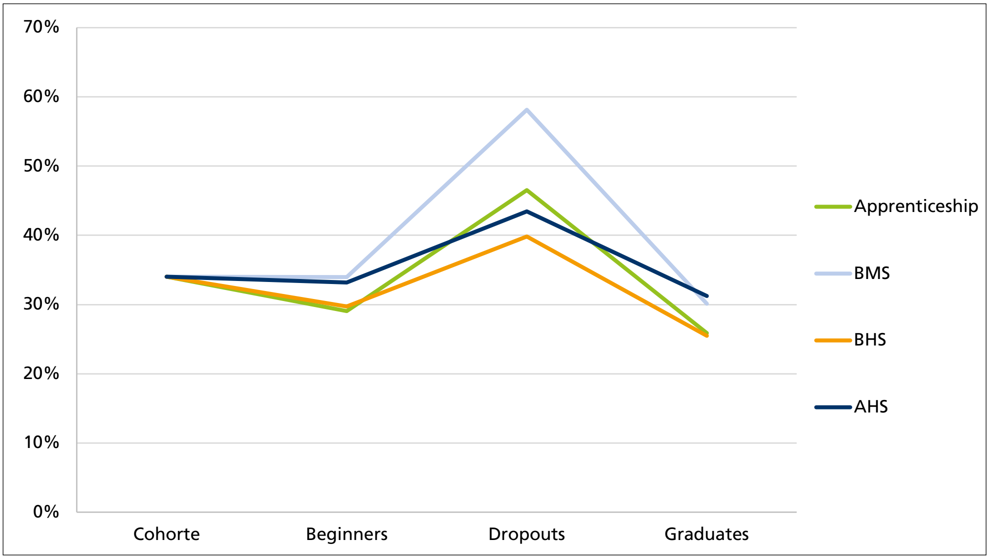
The following figures visualise the respective results:

Figure 1: Selectivity of Upper Secondary Education by Gender in Austria (share of females in %)



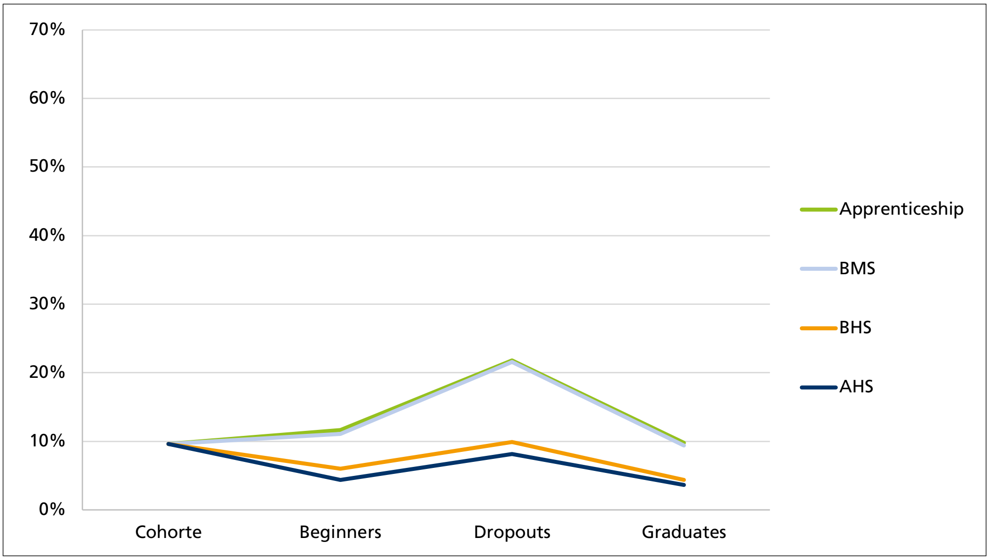
Source: Own representation based on STATISTICS AUSTRIA/AMDC-register-data, N=83,465

Figure 2: Selectivity of Upper Secondary Education by Pupils with Migration-Background in Austria (in %)



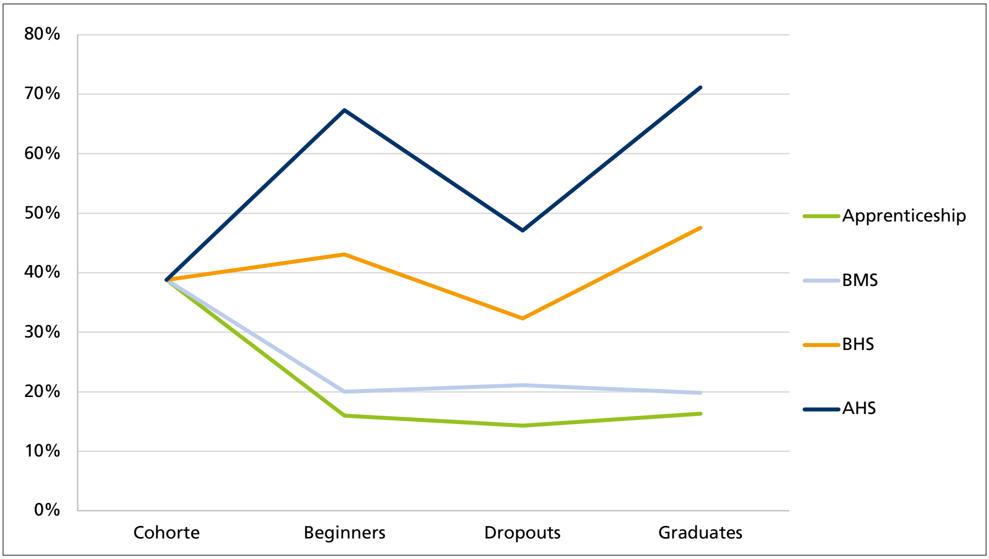
Source: Own representation based on STATISTICS AUSTRIA/AMDC-register-data, N=83,465

Figure 3: Selectivity of Upper Secondary Education by Parents with low level of Education in Austria (in %)



Source: Own representation based on STATISTICS AUSTRIA/AMDC-register-data, N=83,465

Figure 4: Selectivity of Upper Secondary Education by Parents with high level of Education in Austria (in %)



Source: Own representation based on STATISTICS AUSTRIA/AMDC-register-data, N=83,465

3 Conclusions

According to the results presented, social selectivity is high when entering different forms of upper secondary education but is even more pronounced among graduates due to socially unequal dropout rates. When comparing school types, selectivity is once again stronger in the traditionally upper-class Gymnasium than in all vocational education and training programmes. But there are also different trends within vocational forms of education. While the apprenticeship-system and BMS contribute to a certain degree to social equality, at least at the point of entry, social selection in BHS is somewhat lower but overall comparable to those in AHS.

These empirical findings form the basis for policy strategies necessary to counteract social selectivity.

Educational policy should aim at breaking reinforcing dynamics of disadvantage. Thus, social selectivity leads to a concentration of disadvantages in certain school types and locations. Corresponding peer effects undermine aspirations and motivation, leading to an accumulation of disadvantage (see Macleod 1987). On the other hand, latest findings on the influence of social-school-composition on educational trajectories clearly show that disadvantaged students benefit particularly strongly from a more favourable school environment (see Reiter/Steiner 2024). Since counteracting the concentration of disadvantage and promoting greater social mixing has beneficial consequences, it should form a pillar of educational policy.

Investing in early childhood education and expanding all-day school programmes can counteract early differences in performance and competence based on social background. Particularly in the Austrian context, where school entry is characterised by a deficit-concept of testing school readiness (see Steiner 2025) and where half-day schooling especially in primary education is widespread, there is considerable room for improvement.

Finally, based on these findings, it is advisable to promote support programmes that specifically address disadvantaged schools and students. Starting points for this policy have been implemented in Austria as well as in Germany. In the German "Startchancen-Programme", 4,000 schools with a disadvantaged pupil population, representing around ten percent of all schools, receive around € 20 billion in additional funding. Similar Austrian programmes like the former "100 Schools, 1,000 Opportunities" initiative or the programme "Chancenbonus" starting in 2026 appear modest in comparison and should be expanded significantly to reach at least the corresponding size of the German programme.

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Chapter 4: Artificial Intelligence, Emerging Technologies, and Labour Market Impact

Hannelore Kress

Cutting-Edge Integration of Artificial Intelligence in Education – China's Strategies to Steer a Complex System

This article explores how AI is being strategically integrated into China's Vocational Education and Training (VET) reforms to address both industrial and educational challenges. It examines major initiatives such as the Smart Education of China (SEC) platform, legislative reforms, AI-based curricula, and the digital upskilling of educators. Special attention is paid to the policy mechanisms, institutional innovations, and internationalisation strategies that define China's emerging model of technology-driven VET modernisation. Rather than evaluating China's political system, the focus is on the main structural and educational dimensions of AI integration, highlighting lessons, tensions, and opportunities relevant for other countries developing future-ready vocational education systems.

1 Introduction and Background

China has undergone a remarkable reform process in vocational education and training over the past 10 years.[1] During the early 2010s, numerous Chinese delegations visited Europe and especially Germany to study the Industry 4.0 model and far longer analysing the dual system of vocational education. As one consequence, the "Made in China 2025" strategy focused on how to develop and secure a highly trained workforce, which has been presenting significant challenges for China's VET system (Wübbeke et al. 2016).

Various state programmes followed to support a fast transition to a high-tech track answering the industry production needs. One of the many was the Chinese government's "Internet Plus" action plan (approved on 24th of June, 2015). It aimed to integrate mobile Internet, cloud computing, big data, and the Internet of Things (IoT), with traditional industries to promote economic restructuring, improve people's livelihoods, and transform government functions. Internet + Education services should create self-learning and interactive teaching, construct intelligent classrooms or campuses using IT, as interactive on-

1 I acknowledge the use of artificial Intelligence concerning structure and logic, OpenAI, ChatGPT (Version 5.0), April/May 2025) as well as DEEPL AI translation for quality assurance.

line teaching platforms, as provision of education or training services (Zeng/Yang 2015, pp. 42–49; Wang et al. 2016).[2]

The "National Vocational Education Reform Implementation Plan", issued by China's State Council on January 24, 2019, outlined a comprehensive strategy to modernise vocational education.[3] This was followed by other attempts by the state to improve and update the vocational education system as a plan in 2023 to advance in information technology, computer-controlled machine tools and robots, aviation and space equipment manufacturing, and biomedicine (China Daily 2018).

While infrastructure development has been crucial, the challenges of teacher training and convincing families to view vocational education as a viable career path were and are equally important. The urge to act and reform the inert educational system was immense. Over the years, the inability to match the labour market talent made it very difficult for many Chinese enterprises to install and use smart manufacturing technologies. Complex IT processes and computerised machines, such as cross-industry technologies, require detailed expertise in various fields of automation, engineering and software development. Chinese enterprises perceive the skill shortage as one of the major problems for industrial upgrading for both simple automation and highly sophisticated IT-based processes and pressed for more decisive measures (WU 2021). Also, worldwide acting HR-agencies characterise the field of recruitment in China in 2024 by growing demand in several key sectors, underlining the importance of technology and innovation in the country's economy, especially in companies like Alibaba and Tencent focusing on artificial intelligence, big data, and emerging technologies[4].

Over the past two decades, the Ministry of Human Resources and Social Security (MOHRSS) has been tracking the supply and demand for labour in more than 80 major cities in China. Senior skilled workers, technicians and senior technicians were in particularly high demand. Furthermore, the Ministry of Education (MOE) has estimated that China will confront a skilled worker deficit of 30 million by 2025, representing a 48 per cent shortfall in fields such as materials, CNC machine tools, energy-saving and new energy vehicles (Song 2024).

From 2012 to 2021, China has made great efforts to implement the reform of vocational education. By 2021, the country had a workforce of 61 million skilled professionals. The dynamic could be explained by the reform of the Vocational Education Law in 2022 (MOE 2022).

2 Examples of Internet and education Interactive teaching platforms: Focusteach (**https://www.focusteach.com/**), online classes XuetangX (**https://www.xuetangx.com**), VKO – Micro Course.com, (**https://www.vko.cn/**), online training platforms GeekAcademy (**https://www.jikexueyuan.com/**) and China MOOC (**https://www.icourse163.org/**) (all links retrieved on 21.04.26).

3 While the plan does not explicitly mention artificial intelligence (AI), subsequent initiatives and policies have integrated data-driven approaches and AI technologies into vocational education.

4 See URL: **https://www.fitchbennettpartners.com/en/china-recruitment-trends-2024** (Retrieved on 01.06.2025).

Table 1: Areas of Strategic Reforms

1. Equal Status with Academic Education	Vocational education is **explicitly given equal status** to general academic education for the first time.
2. Enhanced Legal Framework	First revision since 1996; introduces **systemic legal protections** for vocational education rights.
3. Industry-School Integration	Stronger promotion of **collaborations between schools and enterprises**, including co-building curricula.
4. Expanded Scope	Includes not only secondary and higher vocational institutions but also **adult education and corporate training** programmes.
5. Lifelong Learning Pathways	Establishes a **flexible, multi-tiered vocational training system**, supporting upskilling throughout life.
6. Credit Transfer & Upward Mobility	Encourages **cross-pathway transitions** (from vocational to academic and vice versa), making it easier to transfer credits and pursue higher degrees.
7. National Qualification Standards	Strengthens and standardises **certification systems** and recognition of professional qualification.
8. Focus on Rural and Underserved Areas	Targets **rural revitalisation** and equal access through vocational training in poor regions.
9. Private Sector Participation	**Encourages private capital** and social forces to enter the vocational education field.
10. Teacher Development and Welfare	Improves **instructors' rights, salaries, and professional development** to attract talent to the field.

Source: Authors' own table based on National People's Congress 2022

Following the 2022 reform, in August 2024, more steps to close the skills gap were taken, like composing pilot programmes and industry education integration with a "Dual New Strengths" Initiative with a structural integration of industry and educational processes (MOE 2024a).

Over the years, enrolment in vocational schools increased. In 2022, 5.46 mio. students enrolled in higher vocational colleges, exceeding the number of those going to a four-year college that offer bachelor's degrees (China Daily 2023). The attractiveness and employability were enhanced as strategic industrial fields like aerospace, intelligent manufacturing were added to vocational tracks. This process was continued so that in 2023, higher vocational schools introduced majors related to strategic emerging industries, including next-generation information technology, high-end equipment manufacturing, new materials and biotechnology (National Bureau of Statistics of China 2024). The sustainability of these strategic outcomes after the implementation for the internal skilled worker labour market is yet to be seen.[5]

All the mentioned reforms not only established structural changes but also at the same time enabled the integration of smart technologies – such as AI, cloud-based learning, and virtual simulations – within vocational institutions. Recognising global trends and national needs, China began embedding AI literacy into its education strategies. In 2025, AI started as a mandatory subject in some regions. It is to be integrated in all primary and secondary schools by 2030 (MOE 2025b). This signals the deepening fusion of digital technology with vocational learning, implementing comprehensive strategies across various academic levels to cultivate a technologically adept workforce.

"We should actively explore ways to go from being a follower to being a leader in areas such as AI legislation and regulation, education and personnel training, and responding to issues with AI" (Ding 2018, p. 31).

As a strategic follow up and aligning with technological progress, China announced its first national action plan to build a 'strong education nation' by 2035. The initiative, introduced by the Communist Party's central committee and the State Council, aims to create a 'high-quality education system' that ranks among the best globally, emphasising accessibility, innovation, and efficiency (Central Committee of The Communist Party of China/State Council 2024[6]). One notable initiative under the 2035 plan is the development of a national, AI-driven learning platform tailored to regional needs, particularly in rural areas, offering free and adaptive educational services.

"Society is generally more concerned about whether students can achieve high grades and whether the skills they have learned will be useful in the future […] and more AI applications are being developed to strengthen test-taking scenarios, help students brush questions more accurately, and obtain deterministic specific knowledge in a shorter way, rather than cultivating students' thinking and exploring the content they are interested in and the larger world. After entering the era of intelligence, this tendency of utilitarian application of AI education may exacerbate the public's anxiety about the direction and method of education" (Tencent Research Institute 2024, p.2).

5 Additionally, China is expanding the international reach of its VET model and positioning itself as an emerging global actor in vocational education. In order to promote Chinese high-tech equipment in other countries and train people on it for operation and maintenance, the government emphasizes since 2016 its internationalization efforts with the "Luban Workshops". The Centers train and educate young people in other countries along the Belt and Road Initiative to work on the extensive infrastructure project (Changbo/Yang 2021) and bilateral agreements on cooperation in vocational education development foster the process of China becoming a leading nation of Vocational Education and Training as a soft power similar to the Confucius Institutes. These centres are operative e.g. in Egypt, Morocco, Kenya, South Africa and Kazakhstan or Portugal.

6 The news comes after data showed that China's population shrank for the third straight year in 2024, with deaths outnumbering births (6.39% births to 7.87% deaths. URL: **https://www.stats.gov.cn/sj/ndsj/2024/indexeh.htm** (Retrieved on 20.06.2025). Experts predict the trend will worsen as high childcare and education costs discourage young people from having children amid economic uncertainties.

2 One Platform for Education

The first version of the 'Smart Education of China' (SEC) platform[7], launched in early 2022, marked the beginning of a comprehensive national strategy to leverage digital technologies in education. By the end of 2023, it had connected over 519,000 educational institutions, supporting 18.8 million teachers and nearly 293 million learners. It recorded 36.7 billion visits and over 100 million registered users from 200 countries (China Education 2024a).

The platform was designed to fulfill five functions, i.e., supporting learning, teaching, governance, research, and outreach and cooperation. The platform also supports graduate job preparation and teacher capacity-building, aligning with national initiatives such as the 'Double Reduction' policy[8], the promotion of 'Digital China', and the cultivation of a nationwide lifelong learning philosophy. In 2023, approximately 19 million teachers benefited from digital training programmes, according to the MOE (2024b).

To further raise teachers' awareness of using digital technology to optimise and reform their teaching activities, the 'Standards on Teachers' Digital Literacy' were issued in 2023. Meanwhile, large-scale capacity-building activities were also regularly organised through the SEC platform to equip teachers with adequate capacity to employ up-to-date smart applications in teaching, with the vision of improving their teaching quality (MOE 2024b).

Building upon this foundation, the National Smart Education Platform was relaunched on 28 March 2024. The first phase of the platform mainly includes four sub-platforms: the National Primary and Secondary School Smart Education Platform, the National Vocational Education Smart Education Platform, the National Higher Education Smart Education Platform and the College Student Employment Service Platform "24365". The second phase of the platform was officially launched on the 8th of July 2024. The new version of the platform provides more cloud resources, mainly focusing on three major areas: Sports, Aesthetic Education, Labour Education, Graduate Education and Teacher Education.

3 AI – Policy and Strategy

To align the vocational education or education in general is a huge task. Despite the growing technological imperative, Chinese researchers argue that the inherent resilience and complexity of existing education systems will delay the rapid integration of AI into vocational education and training. Furthermore, successful implementation will require more substantial investments to modernise training systems and ensure adequate staff training. Again, it is worth looking at the necessary framework for this endeavour initiated by the Chinese.

7 See URL: **https://csmartedu.cn/** (Retrieved on 29.07.2024).

8 The "Double Reduction" policy, introduced by China's Ministry of Education in 2021, aims to alleviate excessive academic burdens on primary and junior secondary school students by limiting homework and restricting private tutoring in core subjects. It reflects broader national goals related to educational equity and social development, including the pursuit of "common prosperity". The policy also significantly restructured the private tutoring industry, transforming it from a lucrative commercial sector into a tightly regulated public service.

The Chinese AI approach tackles the whole society. Unlike democracies that face policy shifts and limitations, China's central government uses "government guidance funds" (GGF) to accelerate AI development while integrating tech companies within the party framework and attracting international talent (Luong et al. 2021).

Already in July 2017, China's State Council released the country's strategy for developing artificial intelligence (AI), entitled 'A Next Generation Artificial Intelligence Development Plan' (State Council 2017). This strategy outlined China's aims to become the world leader in AI by 2030, to monetise AI-related activities and businesses into a trillion-yuan (ca. 150 billion dollars) industry, and to emerge as the driving force in defining ethical norms and standards for AI, including the development of networked products such as robots, identification systems and vehicles; the development of neural network chips that can compete with Western products; the adoption of intelligent manufacturing and investments in standard testing, training and skills, and cybersecurity.

Subsequently, the MOE incorporated "algorithms and computational thinking" into the ICT 'Curriculum Standards for Senior High Schools', signalling a nationwide commitment to foundational AI literacy. As mentioned earlier, China has revised and issued 758 "Teaching Standards for Vocational Education Majors", incorporating digitalisation and AI into curriculum content with general courses on AI and specialised courses on "AI+" in vocational education (MOE 2025b). In a comprehensive so-called "White Paper" of 2025, the MOE again clarifies the multifaceted approach to modernise Chinese education. More than 2,000 vocational colleges offer 97 AI-integrated application-oriented programmes. Furthermore, 866 vocational colleges have launched majors such as AI Technology and Applications (secondary vocational level) and AI Data Engineering Technology (MOE 2025a). Considering the geographical remoteness of the territory, the government also developed the adoption of AI for teachers with a pilot programme 'AI Boosts Teachers' Team Development', aimed "at advancing innovation in teacher education and enhancing students' problem-solving skills. Importantly, both national AI plans emphasize the value of seamless human-AI interaction, while seeking to maximize social and economic benefits and minimize potential negative impacts" (UNESCO 2025a; see MOE 2025a, p. 33).

Some schools in China's remote rural areas already use what is known as a 'dual teacher model'. In this approach, an expert teacher gives a lecture via video link to students in a distant classroom, who receive additional guidance from a less-experienced local teacher. A future possibility could be that an AI teaching assistant supports one of these roles. The AI could help the human teacher with many tasks, including providing specialist expertise or professional development resources, collaborating with colleagues, both within and outside the particular setting, monitoring the students' performance, and tracking progress over time. What and how to teach the students would remain the responsibility and prerogative of the teacher.

One step to encourage the rural teachers was the MOOCs-model[9] providing the necessary broadband connection. The effect on teaching is currently widely researched. The

9 Massive Open Online Course – an online course aimed at unlimited participation and open access via the web.

double teaching method is composed of several small units of expert blogs, including Weibo and online communication (Cheng/Bie 2021). "It is mainly through these small platforms to promptly solve the various problems that appear in the daily teaching and education process for each "dual teacher" teacher, innovate various teaching concepts and thinking under the guidance of experts, and enhance personal integration literacy" (Cheng/Bie 2021, p. 2).

4 Teaching methods to work with AI in the classroom

Worldwide, especially experts in education are concerned how AI is affecting the learning and teaching process. The Chinese Tencent Research Institute launched a series of conferences to discuss the impact and the anxiety of AI in Chinese education. As the director of the Smart Industry Research Center of Tencent Research Institute already stated earlier, rather than enabling deeper learning, many current AI applications reinforce test-centric, utilitarian approaches. Often, AI tools are retrofitted into outdated teaching methods, missing the chance to fundamentally reimagine education for future labour need, importance of flexible and responsive vocational education to meet evolving labour market demands. Stronger partnerships with tech-driven industries, improved social recognition of vocational tracks, and the use of real-world data to communicate outcomes are suggested strategies (Wu/Liu/Deng 2024).

At the same time, China promotes the integration of AI not only in teaching methods, supporting critical thinking, problem-solving abilities and practical skills, but also in administration, assessments and schedule planning (Yimeng 2025). This approach generated critical techniques entering the classroom, e.g., using electroencephalography (EEG). Schools introduced headbands with, for example, 67 sensors worn by the students, allowing teachers to monitor brain activity while students were engaged in tasks. These regulations require parental consent to be obtained before AI technologies are used with students. They also require all data to be encrypted. This has had the effect of halting – although possibly only temporarily – the use of facial recognition and EEG technologies in Chinese schools.[10]

As of the 22nd of August 2019, the central internet information regulator of the People's Republic of China (PRC), the Cyberspace Administration of China, issued the 'Provisions on Online Protection of Children's Personal Information'. The new data privacy regulation "sets forth high-level requirements for the collection, storage, use, transfer, and disclosure of the personal information of children within PRC territory (State Council 2021).

Supporting this shift in strategy, China has established the necessary infrastructure and data storage capabilities within a national big data centre for digital education to promote the integration of information technology and education (MOE 2024b). Additionally, the Faculty of Artificial Intelligence in Education (FOAIE[11]), established in May 2020 at Central

10 See URL: **https://www.wsj.com/articles/chinas-efforts-to-lead-the-way-in-ai-start-in-its-classrooms-11571958181** 2019 (Retrieved on 15.08.2025).

11 FOAIE is a teaching and scientific research unit directly under the leadership of CCNU.

China Normal University (CCNU), functions as a pilot platform for research and education aimed at comprehensive reform and the construction of a "special discipline zone". Its mission is to build an integrated breakthrough platform and a compound talent training model of "AI + Education", establish a pre- and post-service cultivation system for "Future Teachers", and contribute to the development of a National "AI + Education" Centre for technology and innovation.

Extending beyond institutional boundaries, the development of integrated platform resources and services extends into practical, everyday learning environments. These efforts encourage independent schooling and foster interest in science, technology, electronics, and mathematics (STEM), while also supporting students in pursuing hobbies and personal interests during their spare time.

As this vision progresses, China's national strategy for digital education enters its third year. It is transitioning from the "3C" philosophy of "Connection, Content, and Cooperation" to a "3I" approach of "Integration, Intelligence, and Internationalization" (MOE 2024a).

5 Conclusion

China's push to embed artificial intelligence into vocational education illustrates a far-reaching effort to align workforce skills with the demands of a fast-changing industrial and digital landscape. Initiatives like the Smart Education of China platform and dual teacher models show how digital tools are being woven into everyday practice, yet the implementation remains uneven. Gaps between rural and urban areas, questions about teacher readiness, and concerns about sustainable infrastructures persist. While the rapid adoption of MOOCs and AI-based resources signals strong momentum, the long-term success of China's strategy will depend on whether it can balance ambitious top-down targets with practical solutions for learners and teachers on the ground. For other countries, this evolving model offers both inspiration and caution for shaping future-ready vocational education systems.

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Eliminating Language Barriers in Vocational Education by Using Artificial Intelligence

In Germany, exams in VET are generally written in a very complex language. As a result, language barriers present a serious challenge for all examinees, especially for those with limited reading and writing abilities. They need examination tasks that are clear, concise, and easy to understand. Up to now, making examination texts more accessible has been a time-consuming process. Linguists rephrase the texts and professional experts verify that the content remains unchanged. However, by law, they are only allowed to do so for people with communication disorders. The project TOP.KI aims to solve the problem of language barriers in examinations. The team developed an AI-powered tool to assist examination designers. TOP Assist identifies language barriers and suggests more comprehensible phrasings. The tool works with a large language model (LLM) and a database containing thousands of examples of examination tasks.

1 Language Barriers in Written Examinations in Germany

Vocational education and training (VET) examinations in Germany are designed to assess professional knowledge and skills rigorously. However, their linguistic complexity frequently exceeds the everyday language skills of many examinees, especially those with hearing impairments, language disabilities, or limited literacy skills in general (see Schlenker-Schulte 1991).[1]

Complexity in examination texts significantly increases cognitive load, making comprehension difficult, sometimes even preventing people from demonstrating their actual knowledge.

In Germany, VET examinations are developed by volunteer experts. While these professionals are experts in their respective fields, they typically lack specialised linguistic training. Thus, their texts unintentionally contain numerous grammatical, lexical, and syntactic barriers.

To mitigate these language barriers, examinees with communication impairments such as hearing and speech disabilities or autism are eligible for examinations written in plain language. These so-called text-optimised examinations are clear, concise, and easy to understand. But they are not easier in terms of the professional skills they assess. Research has shown that examinees have significantly fewer questions when dealing with text-optimised tasks and solve them more quickly than non-optimised ones. People with limited language

1 AI was used for wording and translation assistance: OpenAI, ChatGPT-4o, Perplexity, Claude 3.5 and DeepL5 (18.03.2025).

skills perform better when tasks are presented in plain language (see Schlenker-Schulte/ Wagner 2006).

However, manual text optimisation is time-consuming, requiring significant linguistic expertise and close collaboration between linguists and vocational experts: linguists rephrase the exams in order to make them clear, concise, and easy to understand. Vocational experts ensure that the revised tasks retain the same technical content and level of difficulty, including professional jargon. This is different from text simplification, which eliminates any lexical challenges a text might possibly contain.

Due to the limited number of specialists capable of performing text optimisation effectively, scalability remains a challenge. At the same time, technological solutions like ChatGPT do not meet the strict legal requirements for confidentiality and data protection associated with the examination system in Germany. Moreover, the quality of the output of ChatGPT and others largely depends on the prompting skills of their individual users. Also, approaches based solely on large language model prompting must rely on linguistic "knowledge" the model has passively acquired. Last but not least, the output of the models is constantly changing due to their rapid development – unpredictably and without transparency or any means of influence for their users.

2 The TOP.KI Project: AI-Assisted Text Optimisation

To address these challenges, the project "Inclusive vocational examinations without language barriers through text optimization using artificial intelligence" was launched in March 2023.[2] Funded by Germany's Federal Ministry of Labour and Social Affairs, the project involves partners such as the Central Vocational Training Committee for Print and Media (ZFA), the Institute for Text Optimization (IFTO), the data analysis startup deepsight GmbH, the Institute for Technologies and Management of Digital Transformation at the University of Wuppertal, as well as the vocational training centres "Berufsbildungswerk Oberlinhaus Potsdam" and "Berufsbildungswerk Leipzig". Together, they are developing a digital assistant called "TOP Assist" that will help examination designers compose clear and comprehensible examination tasks. The software leverages artificial intelligence to automate the process of text optimisation. TOP Assist is constantly being evaluated with regard to its usability and user experience as well as the linguistic quality of the text optimisation.

2.1 Methodology

The automation of text optimisation is achieved through retrieval-augmented generation (RAG). **RAG** is a technique that uses LLMs to **generate** a solution for a given task but to **augment** the model's "internal" knowledge with curated information context that was built using domain-specific information **retrieval** techniques.

So far, research concerning linguistic complexity has not created a definitive list of specific, identifiable factors contributing to the overall complexity of texts. That is the reason

2 TOP.KI website see URL: **https://top-ki.info** (Retrieved on 31.03.2025).

why a system (the “barrier sensor”) was developed to identify the occurrence of a set of linguistic patterns that text optimisation experts deem to hinder reading flow.

The following section provides an overview of the data used as the foundation of automated text optimisation and the ways in which an informative RAG context is built.

2.2 Data

The team uses a parallel corpus of paired texts, i.e., samples that contain texts of original VET examination tasks (“original tasks”) as well as their text-optimised versions (“TOP tasks”). Original tasks were provided by various institutions responsible for developing exam tasks, such as the ZFA. TOP tasks were provided by IFTO. All of these tasks have already been part of actual exams in Germany. The dataset consists of roughly 40,000 task pairs from various professional fields. Task pairs are a valuable source of information as they provide concrete examples for how to optimise a text.

2.3 Generating Context for RAG

On an abstract level, context generation can be considered as a function that receives a text as an input and returns information to the LLM on how potential language barriers can be removed from the given text.

On a concrete level, two separate sets of approaches are used to generate instructive information on how to perform text optimisation for a given text:

- **example-based approaches** using the connected data,
- and **rule-based approaches** using the barrier sensor.

The example-based approaches aim to retrieve a subset of text pairs from the dataset. The goal is to identify text pairs where the original exam tasks are as similar as possible to the given text, to make sure that their respective TOP versions are as relevant as possible to the text to be text-optimised.

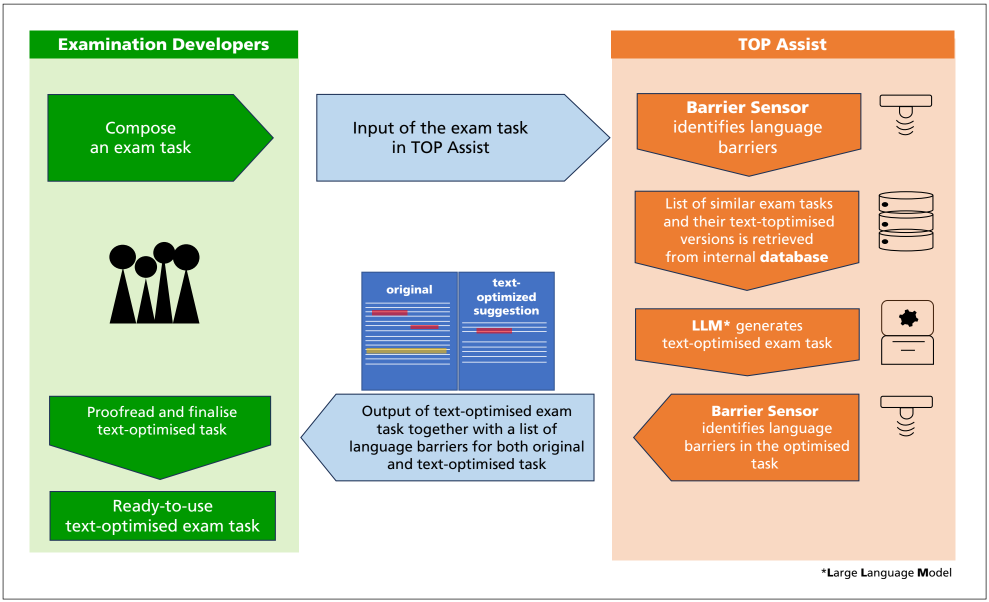
The rule-based approaches aim to provide general information about the text barriers that the barrier sensor identifies in the given text. The information about barriers contains references to the parts of the given text that constitute a certain barrier. It also contains a definition of the type of barrier, how it increases text complexity, and a general template for how to rephrase it.

Once the input text and context have been determined, the next step is to prompt the LLM to generate a suggestion of a TOP version of the input text. For this, some general information about the process of text optimisation is provided, as well as a component for how to interpret the context. The latter varies depending on the type of context used in the text optimisation approach, as the approaches are structurally different. With all information in place, the LLM generates a suggestion of a TOP version, to be evaluated by human agents (such as the authors of the original).

2.4 Using TOP Assist for Automated Text Optimisation

The user interface of TOP Assist is designed to be familiar to users of translation tools such as Google Translate and DeepL. The tool works as follows:

Figure 1: The Tool TOP Assist



Source: Own representation

1. A user enters an original task in the text field.
2. The barrier sensor analyses the original task for language barriers.
3. A list of “similar” tasks and their respective text optimisations is retrieved from the database.
4. The LLM is prompted to text-optimise the original task. In doing so, the LLM draws additional information from the similar task pairs in the database.
5. The barrier sensor checks the text optimisation generated by the LLM for language barriers.
6. The user is presented with the text optimisation generated by the LLM, the list of language barriers in the original text and the list of language barriers in the text-optimised version.
7. Finally, the user can make adjustments to the text-optimised version.

The authors of the tasks remain an essential part of the automated text optimisation process. The software provides suggestions that need to be proofread and, if necessary, adapted by the authors.

TOP Assist can be expanded without any modifications to the underlying language model. Only a few specific task pairs consisting of an original examination task and its text-optimised equivalent are needed to serve as a foundation for the extended context of the new profession or professional domain.

3 Future Prospects: Towards Inclusive Vocational Examinations

Linguistic complexity in German vocational examinations significantly impacts fairness and accessibility. Through advances in language modelling, artificial intelligence-based tools like TOP Assist offer scalable solutions that systematically reduce language barriers while preserving educational rigour. While initially targeting apprentices with communication impairments, TOP Assist could significantly benefit all examinees.

By integrating advanced AI techniques with human oversight within secure infrastructures compliant with stringent privacy laws, TOP Assist exemplifies how technology can effectively foster inclusion in vocational education internationally.

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Helmut Dornmayr and Birgit Lengauer

▶ The Importance of Exceptional Access to the Final Apprenticeship Examination as an Instrument for Securing Skilled Workers in Austria

Exceptional access to the final apprenticeship examination (aoLAP) in Austria enables individuals without formal vocational training to gain recognised qualifications through a second educational pathway. Targeting those with informal or non-formal learning, it enhances employability and supports labour market integration. Based on empirical survey data, this article analyses the demographic profile, motivations and outcomes of aoLAP candidates. It highlights the exam's critical role in upskilling, career mobility, and the validation of prior learning, while also identifying areas for policy and procedural improvements.

1 Vocational Qualification Without Traditional Training – Exceptional Admission via the Second Educational Pathway in Austria

The extraordinary final apprenticeship examination (strictly speaking "exceptional admission to the final apprenticeship examination") is a special form of admission to the final examination in Austria's dual vocational training system. It enables people to obtain a state-recognised vocational qualification without having previously completed a regular (dual) apprenticeship. As a central element of second-chance education, it is aimed in particular at people who have acquired their vocational knowledge and skills outside the formal education system – for example, through practical work experience, semi-skilled work or non-formal further training measures.

1.1 Understanding Second-Chance Education

The term "second-chance education" should not be interpreted in the sense of a deficient or subordinate educational model. Rather, it refers to an equivalent, albeit structurally and biographically different form of educational participation. The term reflects the reality of modern educational and employment biographies, which are increasingly non-linear, fragmented or characterised by multiple reorientations (see Hall 2004; Bliem 2019). In this respect, the second educational pathway can be understood as an expression of individual learning and career paths that are based on practical experience and receive social and labour market recognition through formal certification.

1.2 Labour Market Relevance

Empirical studies in labour market research (cf. e.g. Titelbach/Fink/Vogtenhuber 2021; Bauer/Rulff/Tamminga 2018) show that a significant proportion of the working population performs professional activities without having a formal qualification in the respective occupational field – a phenomenon referred to as formal underqualification. For this group of people, the lack of a recognised qualification often considerably restricts career advancement opportunities, income prospects and access to further qualification measures (see Bauer/Rulff/Tamminga 2018; Dornmayr/Lengauer/Riepl 2023).

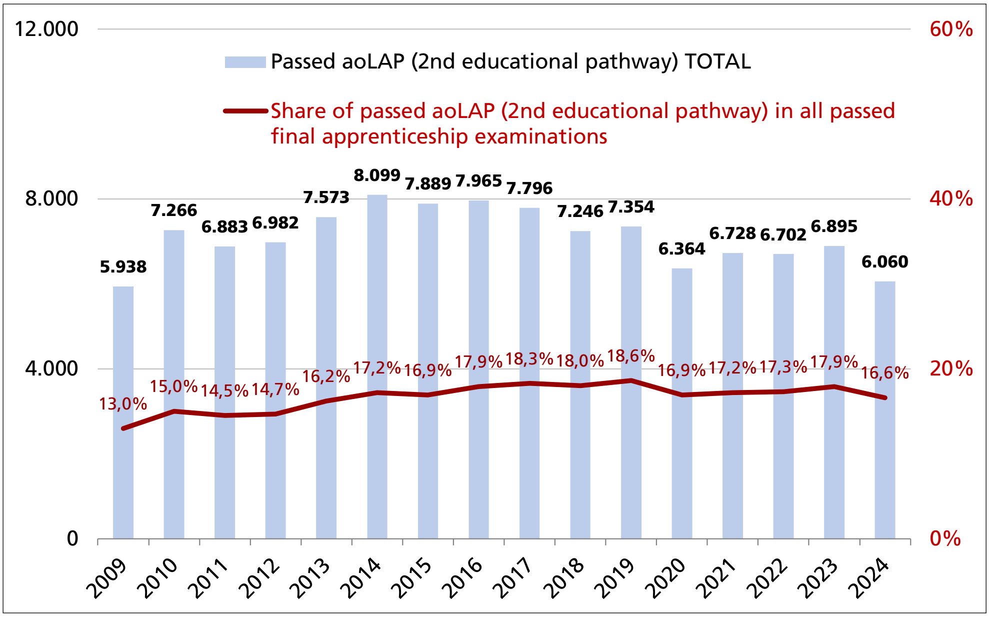
In this context, the extraordinary admission to the final apprenticeship examination (aoLAP) acts as an instrument of upskilling by formally recognising and certifying practical vocational skills already acquired, on the one hand, and increasing professional competence through examination preparation (e.g. participation in preparatory courses), on the other. In this way, it also contributes significantly to labour market integration and occupational mobility within the employment system.

The legal framework for extraordinary admission to the final apprenticeship examination (LAP) is anchored in the respective national vocational training laws, such as the Austrian Vocational Training Act (BAG) § 23 or in comparable regulations in Germany and Switzerland. Admission generally requires proof of relevant professional experience or corresponding qualifications. In Austria, the possibility of extraordinary admission is regulated in § 23 para. 5 lit. a BAG. It states (translation):

> "(5) At the applicant's discretion, the locally competent apprenticeship office according to the place of work or residence shall, as an exception, admit an applicant to the final apprenticeship examination even without proof of the requirements pursuant to para. 1 and para. 3 lit. a and b,
>
> a) if they have reached the age of 18 and can credibly demonstrate that they have acquired the skills and knowledge required in the relevant apprenticeship occupation in another way, for example through a correspondingly long and relevant apprenticeship or other practical activity or by attending corresponding courses; […]." (§ 23 para. 5 lit. a BAG)

In 2024, 6,060 of the successfully completed apprenticeship-leave examinations in Austria – which corresponds to around 17 percent of all apprenticeship-leave examinations passed – took place as part of such an "extraordinary" start in the "second educational pathway" (see Figure 1). This examination route is open to people who have not completed regular apprenticeship training in the relevant occupation but have acquired the required technical skills through alternative routes (in accordance with § 23 para. 5 lit. a BAG). This can be achieved, for example, through many years of relevant semi-skilled work, practical work experience or attendance of specific further training measures.

Figure 1 Passed extraordinary final apprenticeship examinations and share of all passed final apprenticeship examinations in Austria (§ 23 para. 5 lit. a BAG)



(Exam attempts (absolute) and pass rate (relative); 2009 to 2024)

Source: Wirtschaftskammer Österreich 2025 (final apprenticeship examination statistics) and ibw calculations. Own representation

2 Comparative Perspective

Compared to Germany, where around 4.5 percent (17,790 of 394,878) of the final apprenticeship examinations passed in 2022 were external/extraordinary final apprenticeship examinations (cf. Bundesinstitut für Berufsbildung – BIBB 2024), this proportion of final apprenticeship examinations passed in the second educational pathway is significantly higher in Austria (2024: 16.6%). One possible explanation for this difference could be increased catch-up effects, as the proportion of young people who complete dual initial vocational training is generally considerably lower in Austria (cf. Dornmayr et al. 2024).

3 Exceptional Access to the Final Apprenticeship Examination: An Empirical Survey

In Austria, the option of taking an extraordinary apprenticeship-leave exam is one of the most important instruments for validating informally and non-formally acquired skills. To date, very little has been known in Austria about the group of people taking the extraordinary

LAP (aoLAP), their motives, previous experience and qualifications, but also about the consequences of extraordinary participation in the LAP. A study conducted by ibw in 2024, based on an online survey of over 1,000 aoLAP graduates, provides the first well-founded data on this group and their professional development (Dornmayr/Lengauer 2024). The population of the study comprised all persons who took the final apprenticeship examination in Austria in the period 2020 to 2022 as part of the "second educational pathway" in accordance with Section 23 para. 5 lit. a BAG; the online survey was designed as a full survey based on all available email addresses (response rate: 22.3%). The study provides an empirical basis for the extraordinary final apprenticeship examination (aoLAP) in second-chance education and was commissioned by the Austrian Federal Economic Chamber (background information: the apprenticeship offices of the economic chambers (of the individual federal states) act as the vocational training authorities of first instance in Austria, whereby they are also responsible for conducting the final apprenticeship examinations).

3.1 Demographics, Qualifications, and Career Backgrounds of aoLAP Participants

Almost half (48%) of those who took part in an extraordinary apprenticeship-leave exam in Austria in 2020 to 2022 (basic population) were under 30 years old when they first took the exam (the average age was just under 32), 55 percent were male and 45 percent female. Most of them lived in Vienna (35%) or Upper Austria (21%).

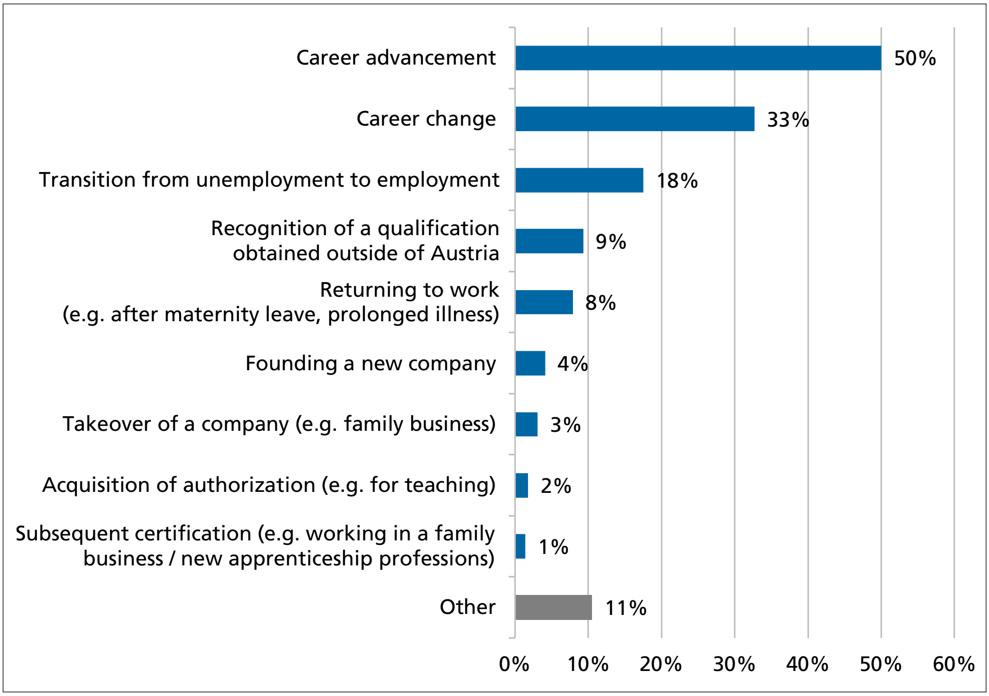
The majority (73%) of respondents who started an aoLAP already had a further education qualification before starting, less than a third (27%) only (at most) a compulsory school-leaving certificate. 28 percent had already completed an apprenticeship in another occupation. "Second-chance education" in the area of final apprenticeship examinations therefore largely does not mean catching up on completely missed (vocational) initial training, but rather supplementing/expanding the existing skills profile ("additional qualification") on the basis of existing secondary educational qualifications.

A total of 43 percent of respondents stated that they had never previously worked in the occupation or in a related field of activity for which they took the final apprenticeship examination (LAP) as part of the "second educational pathway". This group primarily includes those who were seeking to change or enter a new profession through the extraordinary final apprenticeship examination. However, some of these people already had previous practical experience, for example, in the form of internships, or professional experience in other fields of activity.

3.2 Motives and Support Structures in the Extraordinary Apprenticeship Examination

Exceptional access to apprenticeship-leave examinations is characterised by a high degree of heterogeneity and diversity. In the survey, career advancement was cited by half of the respondents as the main motive for taking the examination (see Figure 2), making it the most frequently cited reason (50%). Other key motives were career change (33%), the transition from unemployment to employment (18%), the recognition of qualification or training acquired outside Austria (9%) and returning to work, for example, after a period of maternity leave or prolonged illness (8%).

Figure 2 Main motives for taking the extraordinary final apprenticeship examination (in %)*



**Multiple answers possible*

Source: ibw survey of people who took the aoLAP in the "2nd educational pathway" (§ 23 Para. 5 lit. a BAG) in the years 2020–2022 (n = 1,064; conducted: November 2023). In: Dornmayr/Lengauer 2024. Own representation

Note: Due to multiple answers, the percentages add up to more than 100 percent.

The results of the survey show that there are three main motives for taking the extraordinary apprenticeship-leave exam, which also overlap in some cases: advancement (around half of those surveyed), change of career (around a third), and (re-)entry after unemployment or parental leave (around a quarter).

The primary source of motivation for taking the final apprenticeship examination in the "second educational pathway" was the individual desire to take the aoLAP. Overall, 78 percent of respondents stated that the decision to register for the examination was due to their own initiative. However, external factors also played a role: 16 percent of participants stated that their employers had encouraged them to take the LAP, while 13 percent each cited the influence of their family or the Public Employment Service Austria (AMS; note: Austrian labour market administration) as decisive factors. In addition, eight percent of respondents reported that training providers, for example, as part of qualification projects, had played a supporting role.

Around half of those surveyed (52%) stated that the preparation for or entry to the final apprenticeship examination in the "second educational pathway" was associated with support from the AMS. This support took the form of unemployment benefits or the assumption of course and training costs. AMS support played a particularly important role for people who were seeking a career reorientation or (re-)entry.

3.3 Labor Market Outcomes and Career Impacts of the aoLAP

The majority (95%) of respondents who took an aoLAP examination in the years 2020 to 2022 were subsequently able to obtain a positive apprenticeship qualification and thus an important qualification for the labour market. On a subjective level, there is also a high level of satisfaction with the professional career to date (after completing the LAP): Overall, 84 percent are very or 97 percent are very or somewhat satisfied with their decision to take the LAP in the "second educational pathway". Similarly, 97 percent are very or rather satisfied with the fact that, in Austria, it is possible to take the LAP in the "second educational pathway" and thus "extraordinarily". After successfully completing the LAP, 94 percent are very or somewhat satisfied with their professional career to date.

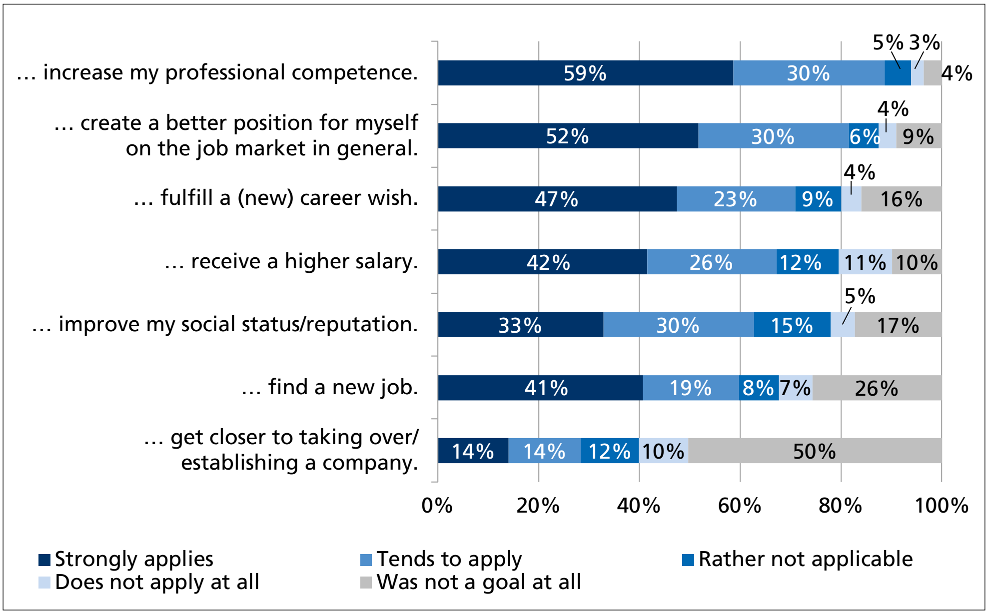
A comparison of the occupational status before/at the start of the final apprenticeship examination in the "second educational pathway" with that at the time of the survey after starting the LAP among respondents who started in the years 2020–2022 illustrates the labour market-related effects of the LAP in the "second educational pathway". The results show that the LAP acts as a stepping stone on the labour market in the "second educational pathway". Specifically, the proportion of respondents employed as skilled workers increased from 36 percent before/at the start of the LAP to 65 percent at the time of the survey (measured in terms of respondents who had successfully completed the LAP at the time of the survey). The proportion of managers rose from 5 percent to 12 percent. In contrast, the proportion of unskilled workers fell from 18 percent to 2 percent and unemployment from 14 percent to 4 percent. These figures show that passing the final apprenticeship examination in the "second educational pathway" is accompanied by an increase in qualifications, which is conducive to labour market integration and career advancement.

At the time of the survey in November 2023, 57 percent of people who had successfully passed an extraordinary apprenticeship-leave exam (LAP) in the "second education pathway" in 2020–2022 were working in the exact occupation for which they had taken the exam. A further 21 percent were employed in a similar or related field. In contrast, 12 percent worked in a completely different occupational field, while 10 percent were not employed at the time of the survey, for example, due to unemployment, training phases or a maternity leave.

The self-assessment of respondents who successfully completed their final apprenticeship examination illustrates the diverse individual and labour market-related effects of this qualification pathway (see Figure 3). For example, 89 percent stated that the LAP had significantly improved their professional skills (rated as "strongly applies" or "tends to apply").

In addition, 82 percent reported an improved position on the labour market, 70 percent saw the LAP as the fulfilment of a (new) career aspiration, and 68 percent stated that they received a higher salary as a result of passing the exam.

Figure 3 Outcome of taking the final apprenticeship examination in the "second educational pathway" (§ 23 para. 5 lit. a BAG) (in %)



Among those n = 930 respondents who stated that they had successfully completed an aoLAP by the time of the survey

Source: ibw survey of people who took the aoLAP in the "2nd educational pathway" (Section 23 para. 5 lit. a BAG) in the years 2020 to 2022 (n = 1,064; conducted: November 2023). In: 2023; Dornmayr/Lengauer 2024. Own represenation

4 Policy Considerations and Development Perspectives for the aoLAP

Options for action and further development of the extraordinary final apprenticeship examinations in Austria include greater involvement of vocational schools in the preparation. In this context, the hitherto little-known option of participating as an "extraordinary student" could be communicated and used more intensively. There is also potential for optimisation with regard to the availability and transparent provision of learning materials and examination content for all apprenticeship occupations, including rare or smaller training occupations. In addition, the advice, guidance and support of groups of people with little educational background in the process of preparing for extraordinary final apprenticeship examinations could be intensified in a variety of ways. Measures for the targeted promotion of these groups could help to reduce existing barriers to access and increase the chances of successfully completing the examination.

A central and multi-layered topic area that may require more in-depth examination concerns the recognition options and admission requirements for taking an extraordinary final apprenticeship examination. A systematic analysis of this type of examination in Austria raises fundamental questions about the recognition and validation of prior learning. In particular, it must be examined whether the existing regulations in the Vocational Training Act are formulated with sufficient precision – for example, with regard to the wording of the admission requirements, which currently include, among other things, a "correspondingly long and relevant apprenticeship". This gives rise to the further consideration of whether greater formalisation and standardisation of the admission criteria would make sense in practice.

The question also arises to what extent access to the final apprenticeship examination should be subject to regulation. This relates in particular to the differentiation and positioning of the extraordinary final apprenticeship examination in comparison to other forms of qualification, such as the (de facto "higher-ranking") master craftsperson examination and proof of competence/qualification examination, which, in contrast to the final apprenticeship examination, are not subject to any formal access restrictions.

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Sabine Kolvenbach and Wolfgang Prinz

Verifiable, Portable, Yours: Self-Sovereign Identity for Lifelong Learning Credentials

Starting with the "Blockchain for Education" initiative, research and educational organizations explored the potential of blockchain technology to secure and verify educational credentials in VET. While these early systems offered tamper-proof certification, they often lacked sufficient privacy protection and did not grant learners control over their data. Drawing on these insights, KUPPEL – funded by the Federal Ministry of Education and Research and coordinated by the Federal Institute for Vocational Education and Training (BIBB) – applies Self-Sovereign Identity (SSI) and Decentralized Identifiers (DIDs) to build a learner-centric credentialing ecosystem. Within this configurable SSI infrastructure, credentials are verifiable, interoperable, and managed directly by individuals, increasing transparency and trust in credentialing processes. This paper outlines how SSI supports decentralized data flows and enables evidence-based VET policy through secure and portable learner data.

1 Introduction

In an increasingly digital and globalized world, educational institutions – including universities, vocational training providers, chambers, and professional associations – face new challenges in verifying educational achievements and credentials.[1] Traditional paper-based certificates or PDF documents are vulnerable to forgery and loss and are often difficult to verify. Historically, quality assurance in credentialing, including the authentication of certificates, has relied heavily on physical security features such as paper quality, holograms, and watermarks, while verification processes frequently involved time-consuming telephone or postal inquiries with the issuing institution. To mitigate these problems, educational institutions maintain long-term registries to enable retrospective validation (see Grech/Camilleri 2017). Nevertheless, for employers and international organizations, authenticity checks often remain slow and are therefore rarely performed – it is estimated that the worldwide fake degree industry has grown from US$1 billion in 2015 to US$22 billion in 2022 (see Greenfield 2023).

Without the adoption of innovative quality assurance mechanisms, educational institutions face serious risks: counterfeit certificates undermine trust in institutional qualifications, manual verification processes are inefficient and error-prone, national differences complicate international recognition, and a lack of digital infrastructure leaves credentials vulnerable to fraud and misuse, ultimately restricting professional and academic mobility

1 GPT-4 was used for formulation or grammar revision especially in Abstract, Introduction and Implications and Outlook in April 2025.

Chambers, serving as key certifying bodies in vocational education, are particularly affected, as their certificates are critical for access to professions and regulated markets[2].

The growing demand for secure, verifiable, interoperable educational credentials and cross-border recognition is driving innovation in educational technology. Blockchain and Self-Sovereign Identity (SSI) technologies offer promising solutions to enable tamper-proof, identity-secure and standardized credentialing systems. This paper presents two pioneering solutions: "Blockchain for Education" platform and the more advanced, identity-centric KUPPEL Certificate Agent, which integrates Decentralized Identifiers (DIDs) and Self-Sovereign Identity (SSI) principles. It then explores how credential issuers such as chambers, as key certifying bodies in vocational education, benefit from SSI and DIDs through enhanced quality assurance mechanisms.

2 Blockchain for Education

The "Blockchain for Education" platform (see Gräther et al. 2018), developed by Fraunhofer FIT in cooperation with Fraunhofer AISEC and Fraunhofer Academy, offers a secure and tamper-proof solution for issuing, sharing, and verifying digital certificates using blockchain technology. It supports the full lifecycle of certification – from course enrollment by learners, the definition of certificate templates by issuers, certificate issuance via cryptographic signing and blockchain registration to revocation of issued certificates and employer-side verification. The system uses Open Badges[3], smart contracts, InterPlanetary File System (IPFS), the Quorum blockchain, and BSCW (see Appelt 2001) to manage certificate data and issuers information, register certificate fingerprints and issuers' digital identity while ensuring learners' privacy. Learners manage their certificates via a wallet app and can easily share them using QR codes and a verification service.

The system is in productive use by the Fraunhofer Personnel Certification Authority[4] and forms the core of DigiCerts[5], a network of universities, research and educational institutions, initiated alongside the "Blockchain for Education" platform to collaboratively develop standards and solutions for secure digital certification processes.

Building upon a similar approach and emphasizing the importance of transparent quality assurance, several Chambers of Industry and Commerce (IHKs), including Berlin, Frankfurt am Main, Rhein-Neckar, and Gießen-Friedberg, have introduced Open Badges. For instance, the IHK Gießen-Friedberg plans to introduce Open Badges for graduates of its certificate programmes starting in 2025[6].

Solutions like "Blockchain for Education" demonstrate that blockchain-based systems could significantly reduce the time and effort required to issue and verify certificates, while enhancing trust in the data's authenticity and integrity. However, they also revealed key

2 URL: **https://www.govet.international/en/190085.php** (Retrieved on 24.04.2024).

3 URL: **https://openbadges.org/** (Retrieved on 16.04.2025).

4 URL: **https://www.personenzertifizierung.fraunhofer.de/en.html** (Retrieved on 16.04.2025).

5 URL: **https://www.digicerts.de/** (Retrieved on 16.04.2025).

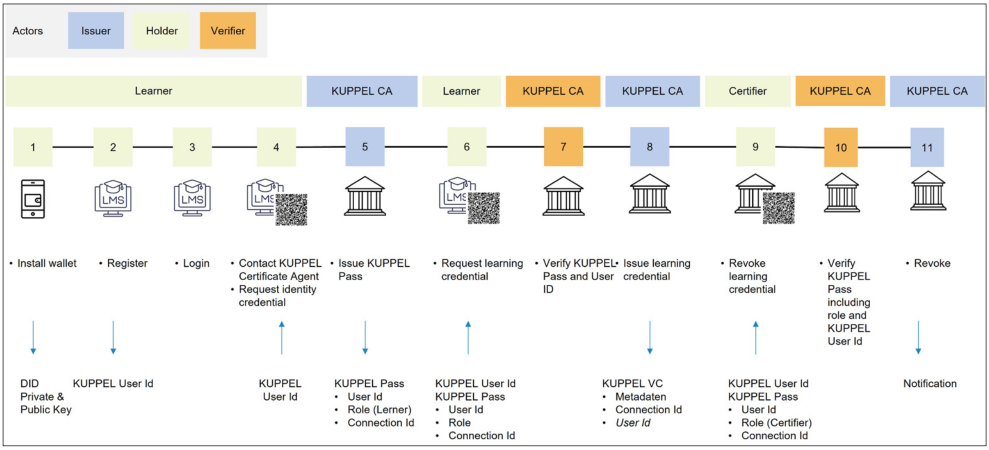
6 URL: **https://www.ihk.de/giessen-friedberg/geschaeftsbereiche/bildung/weiterbildung/downloads/open-badges-6482678** (Retrieved on 28.04.2025).

limitations, particularly the absence of self-sovereign, cross-platform, and privacy-preserving identity management, as well as the issuance and validation of credentials based on the international W3C standards.

3 Advancing to Self-Sovereign Identity: The KUPPEL Certificate Agent

Building on the foundational insights of "Blockchain for Education", the KUPPEL Certificate Agent implements a next-generation SSI architecture tailored to the requirements of VET. It features a modular infrastructure that enables secure and platform-independent issuance, privacy-preserving management, and trustworthy validation of digital, standardized credentials without relying on centralized databases. Anchored in the principle that "the SSI model is very much informed by individuals' needs for security, privacy, and personal data control, the SSI model applies equally for organizations and things. In fact, it applies to anything that needs identity on the internet" (see Preukschat/Reed 2021), KUPPEL follows this paradigm to encompass a wide range of actors and entities – including individuals, certification authorities, and employers – within decentralized, trust-anchored VET ecosystems.

Figure 1: KUPPEL credentialing process with SSI



Source: Own creation using ChatGPT 5.0

Figure (1) illustrates the core steps in the process of all actors in the KUPPEL credentialing ecosystem, including identity creation, credential issuance, verification, and revocation.

The learner's journey begins with the learner installing an SSI-compatible digital wallet that generates a DID and private/public key pair (1). Upon registration (2) and login (3) through the LMS, a unique KUPPEL User ID is created. To initiate interactions with the credentialing service, the learner starts contact with the KUPPEL Certificate Agent by scanning a QR code, triggering a one-time request for a digital identity credential – the KUPPEL

Pass (4). Upon successful connection, the KUPPEL Certificate Agent issues the KUPPEL Pass (5) which contains the learner's User ID and a lifelong personal connection identifier used for all future interactions with the agent, enabling secure authentication and authorized participation throughout the credentialing workflow.

Learning credentials are issued following a two-step verification process: the learner is first logged into the LMS and requests a learning credential by scanning a QR code (6); the KUPPEL Certificate Agent then requests and verifies the learner's KUPPEL Pass (7) before issuing a learning credential (8). These verifiable learning credentials are structured by topic, educational modules, and levels of competence, and they are securely managed by the learner in their personal wallet, enabling selective disclosure and reuse across platforms.

The infrastructure also includes a revocation mechanism. Certifiers can withdraw previously issued credentials by presenting a valid KUPPEL Pass with the attribution of a role as certifier (9, 10, 11). All transactions, including issuance, verification, and revocation, are traceable and cryptographically secured, while ensuring that no personally identifiable information is stored on the blockchain, in compliance with the General Data Protection Regulation (GDPR).

KUPPEL Certificate Agent Version 1 is a modular and configurable SSI infrastructure, built on Hyperledger Aries[7], an SSI infrastructure supporting DIDComm protocol and AnonCreds, and operates on the Indy blockchain. Hyperledger Indy[8] is a purpose-built ledger designed specifically for managing decentralized digital identities[9]. KUPPEL Certificate Agent offers a REST API with an integrated Swagger interface, a user-friendly interface and interactive documentation and testing environment for APIs, facilitating seamless integration with LMS. In addition, the infrastructure includes a dedicated revocation service and a verification webpage for checking the validity of credentials.

KUPPEL credentialing process within the EBSI infrastructure

Aligned with current European trends and strategic developments, Version 2 of the KUPPEL Certificate Agent has been implemented with a strong emphasis on leveraging the European Blockchain Services Infrastructure (EBSI)[10]. As a European joint initiative, EBSI offers a wide range of standardized, interoperable services for implementing digital identities and educational credentials based on SSI principles and the latest W3C standards for Verifiable Credentials and Decentralized Identifiers. EBSI provides also the technical foundation for the secure issuance, storage, and verification of digital identity credentials and educational certificates within the forthcoming European Digital Identity Wallet (EUDI Wallet). It plays a pivotal role, enabling citizens across Europe to seamlessly present trusted digital proofs of their qualifications, skills, and identity in both public and private sector interactions, fos-

7 URL: https://www.lfdecentralizedtrust.org/projects/aries (Retrieved on 22.04.2025).

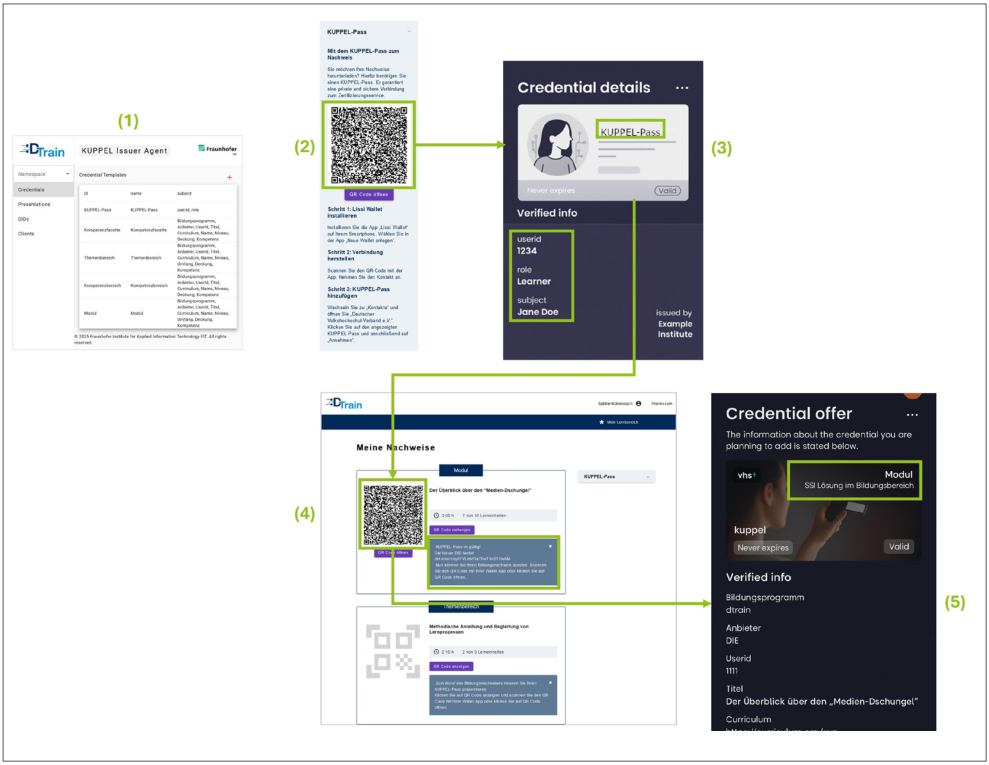
8 URL: https://www.lfdecentralizedtrust.org/projects/hyperledger-indy (Retrieved on 30.04.2025).

9 URL: https://lf-hyperledger.atlassian.net/wiki/spaces/INTERN/pages/21955692/Extending+HL+Fabric+-for+connecting+with+HL+Indy (Retrieved on 12.08.2025).

10 URL: https://ec.europa.eu/digital-building-blocks/sites/display/EBSI/Home (Retrieved on 22.04.2025).

tering greater mobility, transparency, and efficiency in the European digital single market, in line with the objectives of the eIDAS 2.0 regulation (European Parliament and Council, 2024). The integration of the KUPPEL Certificate Agent with EBSI contributes to advancing the European Commission's objectives for a unified digital identity ecosystem.

Figure 2: KUPPEL Certificate Agent integrated with EBSI and credentials managed in the Sphereon Wallet App



Source: Screenshots of the KUPPEL Certificate Agent and the Sphereon Wallet App; own compilation

To realize a proof of concept (PoC) showcasing the applicability of the KUPPEL credentialing process within the EBSI infrastructure, available SDKs for issuing, sharing, and verifying DIDs and VCs have been evaluated. Key selection criteria included open-source availability, support for OID4VC[11], multiple DID methods and signature algorithms, compatibility with W3C standards for Verifiable Credentials and DIDs, and seamless integration with the EBSI infrastructure. Based on this evaluation, the Sphereon Framework[12] has been identified, an open-source SDK for developing SSI applications.

Figure (2) illustrates how the KUPPEL Certificate Agent Version 2 issues Verifiable Credentials. The issuing institution is provided with an issuer agent (1) to define and man-

11 URL: https://openid.net/sg/openid4vc/ (Retrieved on 16.04.2025).
12 URL: https://sphereon.com/ (Retrieved on 16.04.2025).

age the schemas for Verifiable Credentials as well as the Verifiable Presentation definitions in compliance with W3C standards. The issuer's DID is registered on the EBSI network. Learners log into the LMS, e.g., vhs.dtrain[13], to first request their KUPPEL Pass. Within their personal dashboard, they are presented with a QR code linked to the Verifiable Credential offer, a description of the credential, and information about its purpose (2). The learners scan the QR code using their mobile wallet app such as the Sphereon Wallet App[14]. This shows the credential offer. Once accepted, the KUPPEL Pass is issued and stored in the learner's digital wallet (3). It serves as an authorization token that allows learners to request their learning credentials. To initiate the process, the learner scans a designated QR code and presents the KUPPEL Pass to the Certificate Agent (4). Upon successful verification, the KUPPEL Certificate Agent sends the learning credential offer to the learner's wallet app with the full credential details for review and acceptance (5).

4 SSI & DIDs as Strategic Enablers for Credential Quality Assurance

SSI and DIDs represent a significant advancement in the way credential quality assurance can be implemented across educational and certifying institutions. Verifiable Credentials issued using SSI are digitally signed, tamper-evident, and instantly verifiable worldwide. Issuers such as chambers can guarantee that issued certificates are authentic, up-to-date, and revocable. The credential lifecycle is transparent and traceable, ensuring the authenticity of both the issuer and the holder. The immediate, automated validation of credentials increases reliability and reduces administrative workload. Features such as selective disclosure reinforce the role of chambers and educational institutions as trusted certification authorities, aligned with principles of GDPR compliance, privacy by design, and user-centric trust.

5 Implications and Outlook

The shift from issuer-controlled certificates to standardized, user-managed verifiable credentials represent a paradigm change in the way educational qualifications are managed. Projects like "Blockchain for Education" laid the groundwork by proving the feasibility of blockchain technology in education, while KUPPEL extends this foundation by implementing a holistic, identity-secure framework with far-reaching impacts. It facilitates the cross-border recognition of qualifications, strengthens trust and efficiency in recruitment processes, and empowers learners to take control of their private data. This transformation is particularly significant for VET systems, where chambers and competent authorities are central to the certification of skills and qualifications.

Challenges remain, particularly in achieving widespread institutional adoption, ensuring interoperability, and addressing regulatory questions. Continued research, policy sup-

13 URL: **https://www.vhs-dtrain.de/** (Retrieved on 16.04.2025).

14 URL: **https://sphereon.com/sphereon-products/sphereon-wallet/** (Retrieved on 13.08.2025).

port, and collaboration between education, technology, and governance stakeholders will be essential to bring these innovations to scale and realize their full potential.

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Abstract

As we navigate the complexities of globalisation and technological advancement, data has become a critical tool for driving innovation and enhancing vocational education and training (VET) systems. By enabling policymakers, educators, and researchers to make informed decisions, data not only addresses the immediate needs of learners but also plays a pivotal role in shaping the future success of VET. This volume brings together a wealth of global expertise. Featuring 32 articles from a diverse array of countries, this collection offers invaluable insights into the evolving landscape of VET data management and reporting, as well as digital tools and artificial intelligence in VET. Contributors from countries as varied as Austria, Brazil, China, Costa Rica, Germany, Ghana, Israel, Myanmar, South Africa, South Korea, Switzerland, Ukraine, United Arab Emirates, United States of America, Uzbekistan, Vietnam share their experiences and expertise, providing a comprehensive look at the international dimensions of VET data.

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