Lessons Learned from International VET Study Tour: Insights from the Basque Country and Germany

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Abstract: In April 2024, seven U.S. community college faculty representing advanced technology programs were selected as Fellows for an EU Study Tour to the Basque Country and Germany to expand their knowledge of technical education and the adoption of new technologies in a global economy. Participants visited vocational schools and training centers, engaging with European Union (EU) faculty and industry trainers to discuss educational models, curricula, and teaching methods in Vocational Education and Training (VET) programs. Their observations and interaction with site hosts at companies including Festo, Siemens, and SMC, and specialty sites such as Tknika provided insights into advanced technology integration and evolving technician skill requirements and led to their identification of instructional and organizational practices that are potentially replicable in career and technical education (CTE) programs at their home institutions. The Results section provides descriptions of the U.S. faculty's initial efforts at implementing strategies inspired by their observations and comparisons of CTE/VET models.

Keywords: EU, Vocational Education and Training (VET), skilled technical workforce, advanced technological education, international faculty study, curriculum alignment, technology adoption

Introduction

In response to the NSF 19-057 Dear Colleague Letter: International Training and Education in Advanced Technologies (ATE-I) of April 16, 2019, the Preparing Technicians for the Future of Work (DUE #1839567) project Principal Investigator Ann-Claire Anderson submitted a request for supplemental funding for faculty participation in short-term international professional development opportunities. The funding for this activity was awarded July 30, 2020, but travel was postponed until April 2024 due to Covid restrictions. During the COVID period, the awardee organization, the Center for Occupational Research and Development (CORD), commissioned a preparatory study by the Rutgers Education and Employment Research Center comparing Vocational Education and Training (VET) in six EU countries. The project's Community College Faculty EU Study Tour to the Basque Country and Germany was designed to fulfill the project's *Objective 2.4: Benchmark*

European Union models for developing Future of Work-prepared technicians by advancing faculty knowledge about technical education and the adoption of new technologies in a global economy and by identifying instructional and organizational practices that are potentially replicable at their home institutions [1].

Preparatory Research

During the 2020-2021 restrictions on global travel due to the Covid pandemic, the project commissioned a study from the Rutgers Education and Employment Research Center, "Lessons from European States: Policy and Practices in Career and Technical Education [2]." The researchers examined vocational and educational training (VET) across six EU countries through literature reviews and interviews. Their findings provided data and analysis that served as a starting point for shaping the U.S. visiting faculty research questions.

Two notable observations from the study involve adaptability and scalability. During the 2018 Great Recession, "an effort was made to alter the character and structure of European VET systems to promote adaptation to change…This resulted in a variety of shifts and changes to VET policy and delivery structures designed to provide more opportunities for lifelong learning, reskilling, and upskilling" [2]. VET system adaptations to instructional delivery included strategies that are familiar to U.S. community college technical faculty: establishing multiple education entry and exit points, linking VET and regular academic instruction, modularizing the curriculum, giving local authorities and industry the opportunity to influence curriculum to meet their skilled workforce needs; accepting students' prior learning experiences; and offering work-based learning opportunities. Individual colleges or college systems across the U.S. are implementing variations of these strategies, but they are not implemented to scale due in part to the decentralized structure of education nationally, lack of resources, and institutional inertia.

The Global Vocational Education Landscape

Globally, vocational education systems are re-examining their ability to keep pace with societal, economic, and technological changes. The OECD, an organization of over 100 countries (including the US, Germany, and Spain), has called for VET systems to ensure they are future-ready by creating responsive systems, increasing flexibility for inclusivity, supporting transitions, and innovating instruction and leadership practices, see Table 1 [3].

Table 1. OECD Recommendations for Future-Ready VET Systems

OECD Recommendation	Key Elements
Create Responsive VET Systems	• Align programs with changing labor market needs • Develop VET across multiple education levels, including formal postsecondary • Use data-driven approaches to identify skill needs • Engage social partners throughout policy development • Support teacher professional development based on labor market trends
Increase Flexibility for Inclusivity	• Create tailored programs for diverse learner needs • Provide support for at-risk students and those with skills gaps • Facilitate lifelong learning through up-skilling and reskilling • Implement modular approaches and micro-credentials • Recognize prior learning and offer flexible delivery methods
Support Transitions	• Build strong foundational skills for continued learning • Balance general education and vocational content • Develop transversal skills and lifelong learning mindsets • Provide comprehensive career guidance services
Innovate in VET	• Adopt new teaching methodologies and technologies • Integrate simulators, virtual reality, and other digital tools • Implement innovative pedagogical approaches • Develop leadership capacity in VET institutions • Address barriers to technology adoption

Equipped with this extensive review of EU VET practices, awareness of accelerating global technology adoption [4], and understanding of the essential role community colleges play in educating the U.S. skilled technical workforce [5], [6], the project team began its post-Covid planning and implementation of an EU visit to two of the countries profiled in the report – Germany and Spain (Basque Country). It should be noted that while Spain's national policies establish the general framework, the Basque Country enjoys a degree of educational and administrative autonomy, allowing it to tailor VET policies to local needs, economic priorities, and cultural contexts. Both systems are aligned with the Spanish Qualification Framework, which specifies the levels and qualifications within the Spanish education system – both academic and vocational – and the more descriptive European Qualification Framework (EQF), which offers a standardized set of criteria that countries can use to compare and map their own qualifications to the appropriate EQF learning outcomes level [7].

EU Study Tour Focus

VET study tours or exchanges are a common international activity, often organized and promoted by economic development agencies and educational institutions for groups of policy makers, educators, students, and other stakeholders interested in sharing instructional and organizational practices that enhance economic growth. The European Centre for the Development of Vocational Training (CEDEFOP), for example, coordinated study visits for more than 15,000 education and training specialists and decision-makers from 34 European countries between 2008-2014 [8].

The Preparing Technicians for the Future of Work project's EU study tour goals were twofold: to increase faculty knowledge about technical education and the adoption of new technologies in a global economy, specifically Germany and the Basque Country of Spain, and to identify instructional and organizational VET practices that are potentially replicable and would add value to advanced technology education programs at their home institutions [1]. The preparatory research study (literature review, interviews, and analysis) provided the basis for the in-person phase of qualitative research by providing the background for the questions the faculty would formulate for investigation. The Rutgers researchers found a commonality across the six EU member state VET systems they studied: "a move toward flexibility" in program design, pathways to careers, curriculum, professional development, financing, and governance. They recommended that study tour participants explore "inserting and/or centralizing flexibility into US CTE policy and practice [2]."

The question of the adaptability and flexibility of U.S. CTE programs in attempting to replicate EU VET practices is a prominent undercurrent in the research questions posed by the seven community college technical faculty participants [Fig. 1] selected through competitive application. After completing a series of professional development activities, they proposed 1-2 overarching research questions relevant to their discipline, their work as an educator, and the Basque and German training systems to focus their observations while visiting sites and meeting with site hosts. A representative sample of the participating authors' inquiry questions and findings are covered in the Results section.

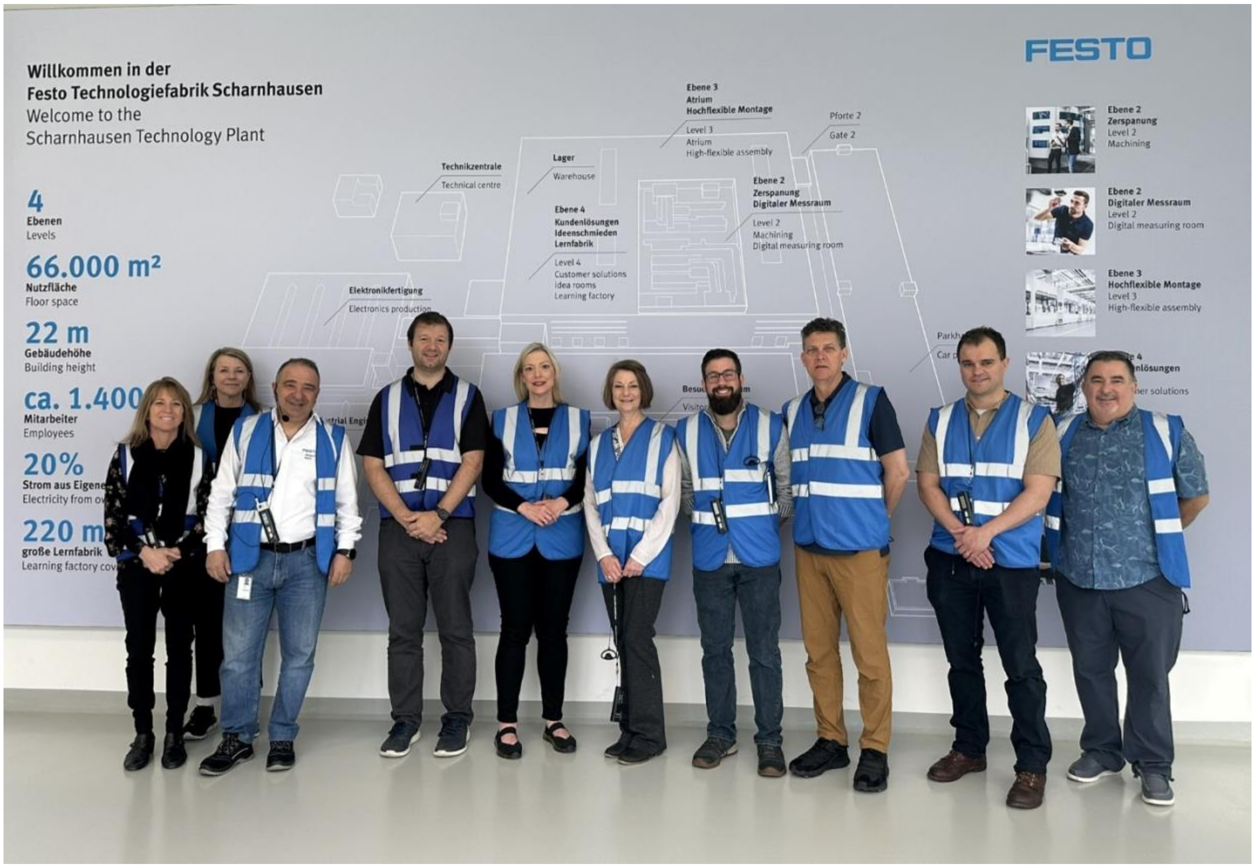

Fig. 1. EU study tour leaders, site host, and U.S. community college faculty visiting Festo Scharnhausen Technology Plant

Methods

Situated within a broad interpretation of social learning theory, the visiting faculty conducted qualitative research related to their individual inquiry questions through direct observation and interaction [9] at the site visits. More specifically, the instructional design of the study tour activities facilitated participant engagement in a cognitive cycle of experiential learning processes in which they were asked to investigate, identify, and implement Basque or German VET structures, policies, or practices. The cycle stages, as delineated by Kolb and Fry [10], were associated with the study tour activities, as shown in Table 2 and culminated in active experimentation through adaptation and/or adoption of promising EU practices following their return to the U.S.

Table 2. Correlation Between Experiential Learning Cycle Phases and the EU Study Tour Activities

Experiential Learning Cycle Phases	EU Study Tour Activities
Concrete Experience – characterized by what Kolb and Fry call "here-and-now" learning experience	1. Visiting VET educational facilities, engaging in industry site tours, meeting employers and industry representatives in Germany and the Basque Country 2. Engaging in cultural experiences to better understand the societies in which the German and Basque VET systems operate 3. Attending Hanover Messe to experience emerging technologies
Reflective Observation – characterized by "collection of data and observation on that experience."	1. Questioning instructors and staff at VET schools and industry sites 2. Observing VET practices, classroom design, and cutting-edge technologies applied in industry on-site visits 3. Writing daily debriefing reports capturing information related to individual inquiries
Abstract Conceptualization – characterized by analysis of the data and feedback to those involved in the experience	1. Discussing and analyzing observations each day as a group 2. Examining challenges to stateside implementation 3. Identifying practices that can be replicated or adapted for use in US CTE programs
Active Experimentation – characterized by modification of their behavior and choice of new experiences	1. Planning for adoption/adaptation of at least one EU VET practice at home institution or system 2. Implementing new practices at their home institution

Following the examples of other successful NSF ATE projects that included international professional development travel, the Preparing Technicians project team facilitated learning activities before, during, and after travel to ensure "participant preparedness, academic rigor, constructive reflection, and collaborative knowledge-building [11,12]." Faculty Fellows participated in visits to educational facilities, industry site tours, and meetings with employers and industry representatives in Germany and the Basque Region. The itinerary showcased a variety of approaches within the German and Basque vocational and educational training (VET) systems, such as the Dual system apprenticeships in Germany and school-based VET programs with strong industry connections in the Basque Region.

A typical visit involved gathering with designated personnel, including SMEs associated with the mission (instructional or production), at each facility. Faculty members attended presentations and asked questions related to their inquiries, which they had formulated prior to the trip. The initial Q&A was followed by site tours and experiences. The methodology maximized information exchange during limited visit times (2-3 hours) and was helpful for site hosts with varying degrees of English proficiency.

Each evening, the group convened to discuss observations and share insights, with an eye toward identifying practices that could be replicated or adapted for use in their colleges' US VET equivalent Career and Technical Education (CTE) programs. The compare/contrast observation protocols asked that faculty observe, document, and share what they learned about:

- Integration of advanced technologies, on the plant floor and in the classroom
- Innovative training strategies
- Cooperation between employers, educators, and government agencies
- Collaborative, hands-on learning
- Competencies – both technical and interpersonal – demonstrated by students
- Methods used for keeping up with advancing technology
- Cross-disciplinary vocational education and training

- Industry involvement in workforce development
- Systems of workforce certification/credit
- School/training facility design
- Curriculum design

To provide context for the educational practices observed, Fellows also engaged in cultural experiences to better understand the societies in which these VET systems operate (e.g., observing the effect of the national pride within the Basque Country on the cohesiveness of the educational system). When they returned to the U.S., they: a) documented key knowledge, b) made plans for implementing or adapting new practices, c) shared what they learned with colleagues and at conferences, and d) began groundwork for implementing their plans.

Companies, Schools, and Special Sites Visited

The project identified potential sites with input from previous NSF study tour leaders, the project's industry advisory board, and companies here in the U.S. that have been CORD partners on technical education projects. Companies, schools, and specialty sites were selected based on their potential to expand participants' understanding of technical education models through interaction with the site hosts (managers, technicians, faculty, and students) and to observe the adoption of new and advanced technologies.

Companies

Corporativo Mondragon is a worker-owned co-operative consisting of over 240 businesses (of which 81 are co-operatives), with a combined workforce of 70,000 people [13,14]. Their industrial division manufactures consumer and capital goods and industrial components. Mondragon also includes education, R&D, and consulting organizations. Training and education are conducted through Mondragon University, a non-profit co-operative private university.

SMC España manufactures, processes, and sells automation control equipment and has collaborated with universities and training centers to formalize internships.

Ibarmia is a machine tool factory using advanced manufacturing technologies, including additive manufacturing, robots/automation, and integrating Smart Factory equipment (i.e., sensors, real-time data analytics, and AI-driven predictive maintenance).

The Festo Scharnhausen factory engineers and manufactures automation components for a variety of industries.

The Siemens AG facility in Chemnitz is known for innovation, such as combining digital twin and AI-based systems to achieve higher efficiency and autonomy in manufacturing processes. At the Consumer Electronics Show in 2024, Siemens announced their collaboration with Sony and Microsoft to develop the "Industrial Metaverse," which uses immersive technologies.

Schools

Miguel Altuna LHII Centro is a Joint State High Vocational Education and Training (HVET) Center with the unique feature of school-wide collaborative challenges aimed at business innovation. The knowledge acquired from the project challenge is disseminated throughout the Center, updating the knowledge base of teachers, students, and partner companies.

Usurebilgo Lanbide Eskola is an Integrated Vocational Training Center that provides initial vocational training (intermediate, higher, and specialized training cycles) and workforce training, offering courses for both unemployed and active workers. It has training cycles for seven industry sectors, which are taught in Basque, English, and Spanish.

IMH is an education center specializing in advanced and digital manufacturing. It draws upon its networks of local and international strategic alliances and offers university, vocational, and incumbent worker training. IMH pioneered Spain's Dual educational model in which teaching is shared between the training center and the company.

Festo Didactic produces technology learning systems as well as online learning content and course curriculum for Festo automation technology employees and customers.

Siemens Education is familiar to companies and colleges for its SITRAIN Digital Industry Academy, which offers a wide range of courses for employees in various technical fields.

Fig. 2. U.S. community college faculty visiting Landarrain Food Innovation Laboratory aquaponics fish and vegetable farm at TKNIKA

Special Sites

Tknika, the Basque Country's Institute for the Innovation of the Vocational and Educational Training System, fosters collaboration between technical faculty and industry to develop projects, expand professional development opportunities, and improve pedagogical strategies [15]. Its project-based learning approach involves collaboration between industry vocational instructors and students in real-world learning laboratories [Fig. 2].

The Mercedes Museum offers detailed information on the history of automotive engineering, including mechanics, electronics, and control systems, plus insights into the intersection of society and technology.

The Hanover Messe is one of the world's largest expositions of industrial technology innovations, offering the chance to network with industry experts from all over the globe and get direct experience or demonstrations of new technologies [16].

Key Features of VET Practices in the Basque Country

Instructional Environment

The government, industries, and schools in the Basque Country are working together to train a workforce for a new era. They recognize that new ways of learning are necessary to support the rapid pace of changing requirements for the technical workforce [17]. Schools like Miguel Altuna specialize in advanced and emerging technologies aligned with local industry needs, featuring facilities housing additive manufacturing labs, collaborative robots (cobots), advanced manufacturing modules from SMC and Festo, and modern "blue" collaborative workspaces. Visiting faculty discussed the replicability of the flexible learning environment that enables quick transformation between instruction, collaboration, and active learning. They also observed that the new equipment available through partnerships is very advanced; thus, using it will equip students for future job roles in technologically advanced workplaces. Advanced technologies are integrated with traditional technologies, including CNC machines and lathes, blending legacy tools with cutting-edge innovations to provide a comprehensive training environment. An example of integrating new and emerging technologies with old training methods and equipment was evident in the machine tool training area. Older milling machines and lathes were outfitted with data acquisition interfaces and stack lights. The system governs student access to machines, records their work time and quality, and assists in the assessment of student progress and material control.

Instructional Design

All VET programs in the Basque Country combine classroom-based theoretical instruction with hands-on, on-the-job training, ensuring students acquire industry-relevant skills and competencies. In the Dual Vocational Training program, students alternate between vocational schools and industry placements, with the proportion of time in each varying based on the program phase and student progress [18]. Programs are divided into modules, allowing students to progress through skill levels, earn certifications for completed modules, and switch between educational layers or pathways. Apprenticeships ensure students gain practical experience while receiving structured academic support, preparing them for seamless transitions into the workforce or higher educational opportunities.

Instructors in the Basque Country are not solely responsible for programmatic innovation. Tknika, a government-funded national teaching and learning center, brings together instructors and industry representatives from across the region, facilitates the creation of a standardized curriculum in emerging fields (e.g., cyber-physical systems, collaborative robotics, augmented reality), makes cutting-edge equipment available, and provides professional development for instructors.

At their Tknika visit, the Fellows were introduced to the Ethazi teaching model, an approach using "High-Performance Training Cycles," which transform the traditional classroom dynamics into challenge-based learning by incorporating real-world problems and cross-disciplinary collaboration [19]. The curriculum is aligned across academic institutions with all students in mechatronics programs, for example, working on the same team projects for a year. In this setting, the instructor functions as a facilitator who guides students through industry-provided projects that intentionally blend the building of technical skills alongside critical transversal or cross-cutting skills that in the U.S. might be called employability skills, including communication, teamwork, conflict management, and adaptability [20,21]. Students work collaboratively to solve complex problems, fostering critical thinking, teamwork, and the development of skills valued by employers [22].

Industry Collaboration

VET schools in the Basque Country work closely with industry and government to ensure their programs remain relevant. Due to strong partnerships, instructors are provided release time to collaborate with experts, which in turn informs curriculum design and practical training, ensuring alignment with labor market demands and a seamless transition for students from education to employment [23]. Schools follow a 65% nationally standardized/35% locally aligned curriculum that promotes consistency but also allows training adaptations to meet the needs of local employers and industry specializations [24]. Institutions like Tknika act as government-coordinated hubs for aligning curriculum directly with industry demands [15,24]. The VET-industry partnerships also focus on preparing students to be part of the global workforce by cultivating relationships with international companies, encouraging students to learn additional languages, and facilitating exchanges, as noted by the Miguel Altuna and IMH schools during the visit.

Supporting Elements

The Basque government provides significant financial support for VET and Dual systems, recognizing their critical role in fostering innovation and driving economic development. Education is free or low-cost to eliminate financial barriers for students and to support local workforce retention. Students participating in apprenticeship programs in the VET system are paid living wages by their employers and are given release time to attend classes at technical schools [18]. Individual schools (e.g., IMH, Miguel Altuna) coordinate curriculum, funding, and professional development directly with the government to align with regional priorities and industry needs. To avoid significant costs to schools, Tknika loans equipment such as hydraulic trainers, welding simulators, and hybrid vehicles to VET faculty.

Key Features of VET Practices in Germany

Instructional Environment

All of Germany's VET programs align education with industry requirements, promoting employability and equipping students with practical, job-ready skills. Technical education can follow a traditional path or what the Germans term the "Dual system" or Duale Ausbildung in which students engage in tightly coupled learning in two locations: the job site and the technical school [25]. Traditional education programs may involve a significant amount of hands-on learning in the classroom, using trainers and other pieces of technical equipment. The Dual System weaves classroom or lab instruction and job experience tightly together, giving students instruction in fundamentals while simultaneously providing practice of those concepts in their actual workplace. Trainers and mentors in companies work closely with teachers at vocational schools to ensure that student progress is monitored in both locations. Responsibility for Dual programs is shared between educational institutions and companies. This collaboration is fully supported by the national and regional Chambers of Industry and Commerce or Industrie- und Handelskammern (IHK), which works to design and update programs in response to changing industry needs.

Instructional Design

Although instructors in the German system often have industry experience and must hold a certification in technical education to be employed at a vocational school, they are not responsible for curriculum development [26]. They may, however, tailor programs to better fit regional industry needs. Students can also customize their experience, entering and exiting the vocational training system at multiple points along stackable pathways.

In the Dual system, apprenticeship programs heavily emphasize workplace-based mentorship and skill acquisition, with companies taking an expanded role in educating technicians. The on-the-job training portions of apprenticeship programs are carefully constructed by individual companies to ensure that students understand their role within the larger enterprise. Learning experiences are designed so that students take on increasing levels of responsibility as they progress through their programs. Apprentices take a written and practical examination (developed by the IHK) to become certified technicians.

Industry Collaboration

Germany's Dual VET and apprenticeship models are globally recognized, influencing similar approaches in other countries with a strong focus on collaboration between schools and industry [27]. Businesses are required to join the IHK and have a vested stake in the structure and design of technical training programs. Employers play a central role in shaping VET programs, with input on training regulations and curriculum alignment with labor market needs. The yearly number of apprenticeship positions in a particular program is based on employment demands and forecasts provided by industry partners. The partnership between government, industry, and the IHK resembles a three-legged stool, with all three entities working on designing, updating, and deploying apprenticeship programs.

Supporting Elements

The roles and responsibilities of trainees, companies, schools, and the government in the VET system are outlined in the federal Vocational Training Act (Berufsbildungsgesetz) [28]. Federal and state governments jointly fund vocational schools, instructor salaries, infrastructure, student support, and support for industry partnerships. Students in the Dual system are paid wages by their company. Benefits are provided by the German social support system, and education at the technical school includes topics like financial planning and fiscal responsibility [29].

The Federal Institute for Vocational Education and Training (BIBB) establishes training regulations and defines standards for recognized occupations [30]. The high level of industry involvement and the standardization of curricula eliminate the need for an overabundance of industry certifications. The VET system also fits within the European Qualifications Framework, which assures companies that skilled workers possess a standardized skill set and vocational qualifications [31]. As a result, graduates completing apprenticeship programs earn certifications that are recognized nationally and internationally, enabling successful job mobility.

Comparing the Basque and German Vocational Education Systems

Both countries take pride in their manufacturing heritages, viewing manufacturing as a core part of their identities and prioritizing development through vocational training that is funded, regulated, and supported by their governments. Collaboration with industry to align training with labor market needs is key to ensuring students acquire practical and job-ready skills. In both regions, this collaboration yields a Dual training system, combining classroom-based education with on-the-job training in companies, with clear coordination between stakeholders. While these similarities are substantial, there are also notable differences between the systems, described in Tables 3 and 4.

Table 3. Operational Differences Between the Basque and German VET Systems

Operational Feature	Basque System	German System
Curriculum Standardization vs. Flexibility	65% national and 35% local curriculum split, allowing schools to adapt training to specific local industries while maintaining curriculum consistency.	Highly structured, standardized curricula and certifications regulated by the Federal Institute for Vocational Education and Training (BIBB) as well as regional chambers of commerce (IHK).
Employer Engagement	Industry collaboration is facilitated through regional authorities and professional learning communities, offering more decentralized and adaptable partnerships.	Apprenticeship model with deep, formalized involvement of employers in curriculum design and training, supported by government incentives.
Focus on Emerging Technologies	Highlights innovation hubs like Tknika, emphasizing applied research and professional development tailored to regional needs.	Focuses on maintaining a national standard for technical and manufacturing excellence.
Funding Structures	Heavily relies on regional government support, with schools coordinating directly with government bodies and industry partners for resources.	Dual system jointly funded by federal and state governments, with additional financial incentives for companies participating in apprenticeships.
Teacher Training and Professional Development	Includes Tknika, a centralized hub for teacher training, curriculum innovation, and technology integration.	Provides ongoing professional development for VET educators, but innovation is more dispersed throughout different regions.

Table 4. Cultural Differences Between the Basque and German VET Systems

Cultural Feature	Basque System	German System
Perception of Vocational Training	Emphasizes the importance of VET as a means of retaining talent and strengthening regional identity, linking it closely to local economic and social cohesion.	VET is deeply embedded in the societal and economic fabric, widely respected, and viewed as a prestigious pathway.
Cultural Integration	Incorporates a strong sense of regional pride and independence, aligning education with local industry needs and values.	Nationally standardized, reflecting a unified cultural emphasis on high-quality manufacturing and economic precision.
Community and Government Role	Emphasis on community-driven initiatives and regional autonomy in educational policies.	Relies on a centralized framework, with significant national and state-level coordination to ensure consistency.

Challenges to Replicating Basque and German VET Practices Nationally in the U.S.

As the faculty Fellows immersed themselves in learning about the characteristics of the Basque and German VET systems, they also compared their practices to technical education at U.S. community colleges. Tasked with finding components that might be adapted for use at their home campuses, they identified serious but not insurmountable challenges due to the differences between the EU and U.S. workforce education systems. They further noted that their institutions, as well as many others, are successfully achieving the same vocational education goals by employing different approaches. Their intent in this section is to examine potential roadblocks to nationwide U.S. implementation of EU VET system features due to differences in system structure, policy, culture, funding, workforce development, and technology.

System Structural Challenges

Decentralized Education System: Unlike the centralized frameworks in Germany and the Basque Country, the U.S. system is highly fragmented, with state, local, and institutional autonomy, making it difficult to establish consistent policies and practices. This is unlikely to change. Instead, U.S. technical educators unite in both regional and national networks organized by discipline and/or industry sector. Some networks are government-funded, and others are not.

Lack of Unified Curriculum Standards**:** The absence of a national framework like the European Qualifications Framework leads to inconsistent training quality and unclear pathways for students across states and institutions. The EU Member States and eleven other countries conform to the EQF, making credentials recognized and transferable to jobs within those countries. In the U.S., industry-recognized skills standards and certification exams might, in some cases, stand in for national technical curriculum standards, but academic and general education standards are unconnected to career and technical education.

Limited Coordination Among Stakeholders: Collaboration between education providers, industry, and government is ad hoc or grant-driven in the U.S., whereas Germany and the Basque Country have structured partnerships facilitated by regulatory bodies and sectoral committees. Recognition of the need for collaboration to meet workforce needs is growing in the U.S., and there are many case studies of colleges partnering successfully to meet advanced technology workforce needs. It is far easier to accomplish this coordination of efforts when the colleges are organized under a centralized state body or funded under a government-prioritized initiative [32,33].

Policy Challenges

Misaligned Definitions and Practices: The U.S. interpretation of "dual education" (high school and college credit) differs fundamentally from the EU model (academic and practical industry training), complicating adaptation. This definition is unlikely to change. There are U.S. technical programs and courses in which academic and industry skills are taught in an integrated manner, but rarely would they approach the Basque or German Dual education model.

Complex Governance Structures: EU technical education systems involve complex layers of governance involving workers, employers, unions, organizations like chambers of commerce, and the state holding relatively equal weight in the administration, governance, and design of VET systems. A flexible VET system is based on shared responsibility between all actors. In the U.S., the difficulty of creating a truly functional interwoven structure creates barriers to the development of cohesive CTE policies and programs. The U.S. is unlikely to institute any kind of national CTE policies other than broad guidelines, except for highly regulated industries or advanced technologies that have national security implications. In the U.S., for example, cybersecurity education features robust collaboration among federal agencies and vetting of community college programs [34], but participation is voluntary.

Cultural Challenges

Public Perception of Vocational Training: Vocational education in the U.S. is often seen as a less prestigious alternative to traditional academic pathways, unlike in Germany and the Basque Country, where it is highly valued.

Competitive Educational Landscape: U.S. colleges and universities frequently view one another as competitors, which hinders collaboration and the establishment of cohesive national career pathways.

Funding Challenges

Inconsistent and Insufficient Funding: EU VET programs provide low or no-cost training to learners to make skills development and enhancement accessible to all potential students. It also considers other indirect costs incurred during training, such as transportation and childcare. U.S. educational institutions rely heavily on tuition, local taxes, and temporary grants, unlike the comprehensive public funding models in Germany and the Basque Country. This is unlikely to change.

High Costs of Infrastructure and Technology: Implementing advanced technologies and building centralized hubs for training and professional development would require significant and sustained investment, which is often politically challenging in the U.S. Partner companies are willing to donate decommissioned equipment to college for training, but that is generally on a college-by-college basis.

Corporate Philosophy of “Rugged Individualism”: Baked into the strong entrepreneurial mindset of U.S. companies is a wariness of cooperation with possible competitors. The challenge for U.S. colleges is to recruit private-sector employers for public-private partnerships, which provide sustainable funding for programs that align with their business interests. These partnerships require effort to cultivate but can provide a stable source of funding when public budgets fluctuate.

Workforce Development Challenges

Limited Apprenticeship Programs: Unlike Germany’s well-established apprenticeship systems, the U.S. has relatively few apprenticeship opportunities, and those that exist often lack standardized frameworks. In the U.S., Registered Apprenticeship Programs are the traditional, federally recognized model of apprenticeship overseen by the U.S. Department of Labor. Industry-Recognized Apprenticeship Programs were introduced as a more flexible alternative with less regulation.

Employer Engagement: U.S. industry partners are not consistently engaged in curriculum design or student training, in contrast to the integrated partnerships observed in the EU. There are industry organizations that have a seat at the table in U.S. discussions of curriculum standards and credentialing exams, but local employers who serve on college program advisory boards are asked to approve curriculum without engagement in its development.

Balancing Local and National Needs: Adapting the Basque 65/35 model (65% national curriculum, 35% local adaptation) would require reconciling regional labor market demands with national workforce priorities. This precise formula would be extremely difficult to enact. National workforce priorities shift with changing U.S. administrations and new technology R&D, and Congressional funding for workforce development and training reflects these shifts.

Technology Challenges

Delayed Adoption of Emerging Technologies: U.S. community colleges often lag in adopting advanced technologies like digital twins, cobots, and VR/AR due to financial and logistical constraints.

Lack of Centralized Innovation Hubs: The absence of facilities like Tknika limits opportunities for educators to collaborate, experiment with emerging technologies, and design problem-based learning projects. In the U.S., it is possible that federally funded Centers of Excellence or Advanced Technology Education Centers or partnerships with research universities could serve this function.

Discussion

The feasibility and appropriateness of integrating the the observed German and Basque VET policies and practices within U.S. programs necessitates careful consideration. While significant obstacles exist, the potential advantages of overcoming these challenges are substantial and warrant investigation. The visiting faculty, through pre-tour readings and research combined with on-site observation and reflection, gained valuable insights into the complexities of adapting and applying European Union education strategies within the context of U.S. community colleges. They envision a range of collaborative stakeholder activities that will potentially yield benefits, including improved labor market outcomes, enhanced access to education for opportunities in high-paying advanced technology careers, increased instructional flexibility and individualization, strengthened education and industry partnerships, and improved quality and innovation in career and technical education.

Recommendations

Their key recommendations reflect their analysis of implementation feasibility and appropriateness and emphasize the importance of college-led innovation, industry engagement, and policy-level support for U.S. technician education programs, now and in the future. Note that U.S. community colleges are implementing many of the strategies seen in the visit to some degree, and the recommendations reflect the need to study and expand their use.

College-Led Innovation

In the EU, modular and flexible curricula allow students to progress at their own pace, switch pathways as needed, and earn credentials incrementally, much like stackable credentials in the U.S. Furthermore, the EU schools' exceptionally strong VET partnerships with companies provide program access to expensive equipment and advanced simulation tools used in modern industry. In the Basque VET system, essential 21st-century skills are embedded within curriculum frameworks. Community colleges in the U.S. are implementing all these strategies to some degree, and the recommendations reflect the need to expand their use.

Initial Steps for Colleges

- Expand the availability of career pathways with multiple entry and exit points conferring stackable credentials.
- Cultivate more than "silent partner" industry involvement in technical programs.

- Incorporate digital twins and virtual platforms to provide remote access to training tools to provide authentic training experiences for students.
- Embed contextualized curricula with core and 21st-century skills (e.g., problem-solving, math, and science foundations) to align with industry needs and prepare students for industry.

Industry Engagement

To effectively address workforce needs, strong stakeholder engagement is crucial. Establishing Regional Industry Councils comprised of industry leaders, educational institutions, and government representatives modeled after the German BIBB would guide curriculum design and training priorities, ensuring alignment with the evolving labor market. Employers and educators would co-design apprenticeship and internship programs. Collaboration would be extended via professional learning communities that facilitate knowledge sharing and collaboration among educators and industry leaders, foster the integration of emerging technologies, and support the development of innovative teaching practices. U.S. community colleges employ a variety of approaches to employer engagement, as represented in case studies [35], [36], [37], [38], some of which contain many of the elements of the German VET system.

Initial Steps for Industry Partners

- Participate actively on college technical program advisory boards to shape curricula and training programs, ensuring alignment with real-world industry needs.
- Partner with schools to create robust apprenticeship programs that integrate hands-on work-based learning with academic education.

Policy-Level Support

Effective policies are essential for establishing and sustaining a strong technical education system. Adopting a national framework for U.S. career and technical education, like the European Qualifications Framework, would standardize certifications and define clear skill levels. A standardized U.S. framework would establish clear pathways that integrate vocational and academic education, allowing for the accumulation of stackable credentials leading to higher qualifications. Regional workforce needs could still be addressed within a standardized national framework by implementing a model like the Basque 65/35 curriculum split. That said, there would be challenges to implementing a national system for U.S. career and technical education, as noted in the System Structural Challenges section above.

Centralizing funding and governance would promote equitable access across regions and encourage collaboration rather than competition among educational institutions. Funds from federal initiatives reminiscent of the CHIPS Act and other relevant programs could be used to establish EU-style hubs for professional development and training in high-demand fields like semiconductor manufacturing, biotechnology, and cybersecurity. Public-private resource sharing through "hub and spoke" models, where centralized hubs house expensive technologies accessible to all regional stakeholders, would significantly reduce duplication of costs. Additionally, providing financial support to students, as in the Basque approach, would make education affordable and ultimately increase the availability of skilled technical workers.

Initial Steps for Policymakers

- Promote policies that facilitate partnerships between universities, community colleges, high schools, and industry to create seamless education-to-career pathways.
- Strengthen public-private partnerships through incentives like tax benefits and subsidies to encourage companies to actively participate in training programs and contribute shared resources.
- Provide access to virtual tools and simulations to enable authentic training experiences for students and educators, particularly in remote or resource-constrained settings.

- Establish a centralized hub, like Tknika, for professional development where educators can access cutting-edge technologies, collaborate in professional learning communities, and design innovative projects.

Results

Two of the expected outcomes of the community college faculty study tour to the Basque Country and Germany were the formulation and investigation of personal inquiry questions, as well as the development of plans to implement a promising practice observed during on-site visits. The following questions are examples of participant inquiries for investigation at the EU sites, along with summaries of their related observations and post-visit analyses.

What professional development models are utilized in Spain and Germany to equip educators with the skills and knowledge needed to teach emerging / interdisciplinary technologies in manufacturing and IT sectors?

In both Spain and Germany, strong relationships and collaborations between VET sites and employers help to align curriculum and instruction to real-world industry needs. Employers share insights into current technological trends and advancements and their practical applications for integration into the curriculum. They also provide hands-on professional development opportunities by working alongside faculty on real-world projects (or challenges) focused on emerging technologies. This is achieved through externships or through paying faculty members to work on a project with a representative from the company.

In the Basque region, Tknika, comparable to a national Center for Teaching and Learning, offers faculty impressive instructional resources and continuous professional development in a wide range of emerging and cross-disciplinary technologies, including Industry 4.0, robotics, digital manufacturing, biosciences research, virtual reality, biomedical, IoT and automation, and cybersecurity. Faculty have access to centralized resources and partnerships with deeply committed companies. During our site visits, we observed that collaborating with researchers, instructional design experts, and business and industry to develop and update curriculum helps standardize content, allowing VET faculty to concentrate on teaching rather than constantly revising and updating their courses.

In the German Dual system, companies work with educators to co-develop curricula, offer training workshops, and provide industry placements in externships. As in the Basque region, these relationships and collaborations help ensure that instructor knowledge and skills on the latest industry trends are continuously updated. The difference is that in Germany, the professional development opportunities for faculty are offered by many of the leading companies, whereas in the Basque region, Tknika serves as a central hub for professional development.

How does Germany propose to increase VET educational program adaptability without compromising the program structure that employers rely on to verify employee qualifications?

The German technical education system structure is so intricately integrated with its advanced manufacturing industries that it almost renders the question moot. Most of the curriculum is standardized by governmental bodies whose members include representatives from both technical education and industry. The standardized curriculum includes core concepts foundational to advanced manufacturing, which are necessary regardless of advancements in technology applications. The remaining curriculum is adaptable by individual Dual educational programs. These programs involve apprenticeships in which students rotate frequently between industry jobs and classes in the schools. Companies that host apprenticeships have structured internal programs and processes that ensure students receive cutting-edge technology application exposure and training, as well as rich company experiences across disciplines. At the end of these Dual programs, students are given standardized tests and receive a government-approved certification that all industries in Germany recognize and respect. It appears that most apprentices begin full-time employment at the company where they apprenticed, but they are free to seek employment elsewhere if desired.

How can the U.S. modularize program content without compromising the agility necessary to keep pace with the fast pace of change in advanced manufacturing?

In both the Basque Region of Spain and Germany, the key to the success of their impressive technical education systems appears to be rooted in shared goals and ideals for their countries as a whole. Industry appears to understand the importance of providing rich experiences and opportunities for tomorrow's workforce in order to secure a successful manufacturing environment (and all that goes with it) in the future. The U.S., especially at the state and regional level, would do well to take note of the effectiveness of supporting technical education in a cohesive manner. Industry sectors in community college service regions need to come together and agree on program content, including stand-alone industry certifications. Hosting interns and apprentices needs to be seen as essential to agility and future business growth, not a burden that takes full-time employees away from their more important duties.

As workforce intermediaries, CTE faculty are often caught in the middle between providing appropriately trained employees who can hit the ground running and meeting academic system metrics, which do not always translate to recognizable benefits to employers. Industry employees can contribute to continuously on-point technical education by serving as adjunct faculty alongside college instructors. While college faculty maintain the required academic course structures, the industry adjuncts provide lessons on technology applications and business/manufacturing processes.

How can educational systems at all levels reform vocational training with a collaborative effort to enable clear and efficient pathways through the K-12, joint technical education, charter schools, community college systems, and public and private universities to prepare semiconductor and optics technicians for meaningful employment?

In Germany, students have pathways mapped out starting in 4th grade. At one industrial training center, we saw a complex graphic aligning their offerings with levels within the educational pathway system. The United States would greatly benefit from this level of classification and a requirement that all training partners level-set their training courses within a common framework. At the same time, in the U.S., the drive for credentials and micro-credentialing is being driven by education and not industry. We repeatedly asked both educational partners and industry on the study tour, and they affirmed that, in most cases, credentialing of any kind is not a condition of employment. Of course, in EU systems, employers are already working hand-in-hand with training centers, so they do not need certification to know that the training is of sufficient quality. Perhaps instead of new credentials, stronger industry partnerships and more instructional coordination are needed in the U.S. Given the fiercely independent views of local colleges, it will be important that coordination efforts allow each college or training partner to maintain something of its unique identity. One way to accomplish this would be by applying the 65/35 model we saw in the Basque region. Another way would be to establish state-funded training centers specifically designed for professional learning communities with externships and collaborative spaces for teachers to learn about new technologies and develop problem-based learning projects for individual implementation.

Specific to semiconductor manufacturing, there are some regional efforts at coordination in the United States. In Maricopa County, a group has just started under the leadership of the Center for Semiconductor Manufacturing at the University of Arizona. In addition, the US NSF ATE program has funded national and regional centers to conduct coordination efforts in a wide range of advanced technologies. The challenge, at least for the near future, is to support these colleges and help them see the benefit of collaboration rather than seeing it as harmful competition.

How do vocational institutions decide what should be covered at school and what should be covered in OJT? What makes local VET institutions responsive to changing needs?

Collaboration between industry and vocational institutions is much tighter in both Germany and Spain and possibly more broadly throughout Europe. On the EU Study Tour, participants saw industry actively present in each vocational school that we visited. When we visited industrial sites, we saw evidence of active participation and collaboration from vocational educators. In some cases, the same curricular graphics were displayed on the walls, student projects were visible in both locations, and companies had dedicated trainers who worked closely with their counterparts at vocational schools.

Furthermore, companies in a region had dedicated staff that were tasked with training and onboarding apprentices and managing their progression throughout the system. These trainers would align on-the-job training with activity at the VET school, meet with students, measure progress, and share feedback with instructors so that gaps identified on the job could be remedied at school. This resulted in representatives from companies meeting with faculty *several times per week* to ensure that students progressed appropriately. The result is that graduates who obtain an apprenticeship certificate are fully qualified for employment. There is simply no question about readiness due to the trust and interconnections between industry and academia.

Several factors contribute to this strong connection. Most notably, these collaborations do not arise organically. Government agencies or industry groups require that companies work closely with VET programs. For example, in Germany, manufacturing companies are required to pay dues and join the IHK. The IHK then forms groups of industry professionals and academics to write the apprenticeship certification exams, standardize certain aspects of curriculum, and ensure that programs are responsive to industry needs.

Post-Tour Adaptation Efforts

The EU Study Tour is yielding both immediate and expected longer-term, developing outcomes. The application of lessons learned by faculty visiting German and Basque facilities illustrates the value of an international study tour. The site visits allowed them to observe innovative teaching methods, state-of-the-art training facilities, and effective industry-education partnerships. Fellows identified several practices they believed could be adapted for use in U.S. community colleges. It is worth noting that they have many years of teaching experience and are now in positions of influence at their colleges. A quick start to the implementation of new practices might prove more challenging for less experienced faculty.

Ethazi Challenge-Based Learning Approach

The faculty at Moraine Valley Community College (IL), for example, is revising a robotics course in collaboration with industry partners by incorporating the Ethazi challenge-based learning approach. The enhanced course will include real-world challenges that require students to program robots for authentic manufacturing tasks identified by local businesses. Using a scaffolded approach, the updated curriculum will equip students with practical programming and troubleshooting skills that convey industry-recognized credentials, foster collaboration and teamwork, and enhance the soft skills valued by employers.

New Registered Apprentice Program

The Community College of Allegheny County (CACC) has collaborated with the German American Chamber of Commerce (GACC) for many years, creating and implementing apprenticeship programs in mechatronics, polymer technology, and sales engineering [39], [40]. Following the EU Study Tour, the college and the GACC-Pittsburgh launched the first registered apprenticeship program in electric vehicle technology in the U.S. [41]. This program is heavily modeled after the German system and involves two collaborative international visits. CCAC faculty visited EV education programs in Germany, and a German *meister* (authorized to train apprentices) traveled to CCAC to provide a two-week training program for faculty.

Semiconductor Pathway with Coordinated Professional Development

Several initiatives with components inspired in part by the EU visits are underway at Rio Salado College (AZ). The college leadership, along with leaders from the University of Arizona Center for Semiconductor Manufacturing, is collaborating with Chandler-Gilbert Community College, Chandler Unified School District, Northern Arizona University, and more than a dozen industry partners to establish a Career and Technical Education pathway focused on semiconductor manufacturing [42]. The pathway will integrate core skills aligned with IEEE standards, problem-solving, and 21st-century skills into a curricular framework with course sequences leading to 2-year and 4-year degrees and also to registered apprenticeship programs that allow students to work for an industry partner while taking classes [43]. Another promising development for the Maricopa Community College District, the Future48 Workforce Accelerator for Semiconductor Training, demonstrates the value of policy-driven workforce development investments. The facility received substantial funding from the Arizona Commerce Authority, the Arizona Governor's Office, and through congressional appropriations [44]. In addition to hands-on skills training, the site will host a Tknika-like professional development model, bringing educators and employers together for networking and collaboration on joint projects and other initiatives that lead to continuous improvement for both educational institutions and businesses.

Industry Cooperation and Flexible Classrooms

The EU Study Tour revealed that close cooperation between academia and industry to identify immediately relevant skills increases global competitiveness in advanced manufacturing. Recognizing that a better-prepared workforce will be needed to help the U.S. reach its onshore manufacturing goals, Central Virginia Community College is piloting a new course replicating elements of the EU model. The course incorporates Python, Excel, and AI tools to teach production data collection, management, graphical analysis, and security using production data generated by industry partners. Inspired by the flexibility of the instructional spaces at Tknika, the college has also converted a computer lab in the Mechatronics area into a flexible lab/classroom space, which includes flip-top tables that can be stacked tightly against one wall. Overhead reels with 208V and 120V retractable cords power various training stations safely. Tables, chairs, and equipment racks are all on heavy-duty casters, enabling quick reconfiguration of the space. The design increases the amount of training equipment available for instruction without heavy construction required.

Conclusion

The EU Study Tour provided an invaluable exchange of ideas and best practices between EU VET practitioners and U.S. technical faculty. Experiencing industry and education sites firsthand enriched the faculty's understanding of multi-faceted approaches to workforce development and inspired innovative solutions to shared challenges. They observed the seamless integration of both new technologies and 21st-century soft skills into technical education programs. They also noticed the benefits of well-developed, ongoing collaboration between employers, educators, and government agencies in which each partner plays a role in determining skills standards, developing curriculum, providing work-based learning experiences, supporting faculty, and procuring program funding. Overall, the experience broadened the perspectives of faculty visitors on technical education and helped them consider ways to improve their own programs by adopting or adapting EU VET practices or systems.

By engaging with U.S. educators, our European hosts gained valuable insights into the American educational system while also showcasing the unique strengths and innovations of their own institutions. This cross-pollination of ideas ultimately benefits students on both sides of the Atlantic, helping faculty equip them with the knowledge and skills necessary to thrive in an increasingly globalized society. The visits established connections between U.S. educators and their European counterparts, laying the groundwork for potential future collaborations. Comments from our EU colleagues [Table 5] reinforce how international exchanges foster global collaboration and help faculty prepare students for an increasingly interconnected world.

Table 5. Post-visit Reflections from Basque and German Site Hosts

Site Visited	Host Comments
Tknika	The visit from the U.S. college educators' team was a unique opportunity to exchange knowledge and explore best practices in workforce and technology education. It reinforced the importance of global partnerships and inspired us to adopt new approaches to meet emerging challenges in training highly skilled technicians.
IMH Campus	The visits of teachers worldwide to industrial vocational training centers, such as the U.S. college educators stage in The Machine Tool Institute (IMH), offer numerous benefits for both educators and students. Teachers have the opportunity to learn about different socioeconomic and cultural realities, as well as to acquire new teaching methods and innovative practices that they can implement in their home institutions. This translates into a more enriched and up-to-date education for students, who gain knowledge aligned with global labor market demands and a broader perspective of the industrial sector. Moreover, such visits foster dialogue on common challenges, such as the integration of advanced technologies, directly benefiting students by equipping them with the most modern tools and skills. Finally, these initiatives strengthen the creation of international networks.
SMC	Both the EU and the USA are experiencing a similar surge in the demand for skilled workers in automation and manufacturing. The shared vision of the Basque administration, VET colleges, and local companies, like SMC International Training, has led to the development of effective up-skilling programs for teachers, as well as robust infrastructure and curriculum for students. This collaborative effort has successfully met the technical workforce needs of industries in the Basque Government over the past decades.
Siemens	Thank you for allowing us to introduce our company's internal training philosophy, including the involved institutions. It was of great value to dive into discussions about various approaches and gain new insights for our own work. Even during the lunch break, we couldn't put the topic aside and had valuable conversations, compared, and made connections.
Festo	[…] we had the opportunity to share insights on trends in automation, mechatronics, Industry 4.0, robotics, and related technologies with the CORD delegation during your visit to our booth at the Hannover Fair. Last but not least, meeting passionate individuals who contribute to the U.S. educational system by exploring different systems and seeking alternatives, options, and related activities truly makes a difference. I would like to summarize the CORD visit with the phrase "Thinking and acting beyond borders."

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