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Environmental Engineering Education in Türkiye within the Framework of Capacity Building in Vocational Education and Training (CB VET) Approach

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Abstract

In this study, the current structure of environmental engineering undergraduate programmes in Türkiye has been evaluated in a multidimensional manner through informal interviews with graduates and sector representatives and data-driven analyses from open sources. Within the scope of the study, the capacity building in vocational education and training (CB VET) approach, which attaches great importance to the improvement of vocational and technical education, was evaluated as an important approach that could increase the institutional capacity of environmental engineering programs. According to this competency-based education model, specialization of faculty members, regular feedback from the sector and graduates, improvement of laboratory and field facilities, and dissemination of long-lasting workplace practices such as 7+1, which accelerate the processes of students learning to solve problems and gaining experience in the field, are important. Accreditation processes such as MÜDEK and ABET institutionalize continuous improvement cycles for programs and thus ensure that the curriculum remains up-to-date. In conclusion, adopting the CB VET approach in environmental engineering programs in Türkiye will be a strategic step in training engineers who are sensitive to current environmental problems and have high industry skills with a level of quality assurance that meets international standards. In this way, both students with the competencies demanded by the industry can be graduated and their employability can be increased, and the lack of qualified human resources in the implementation of national environmental policies can be resolved.

Key Words

Education
Capacity building
Environmental engineering
Vocational education and training
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About Article

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Introduction

For a long time, there has been a disconnect between theoretical education and practical sector needs in engineering education in Türkiye. This situation is noticeable in different sectors for different engineering fields. Graduates of engineering departments usually graduate without sufficient practical knowledge and as a result have difficulty in adapting to the sector in business life. In addition, due to the differences among university programs, there are also inconsistencies between the qualifications of engineers graduating from different universities. Due to the inadequacy of practical education, limited sectoral cooperation in education and insufficient institutional infrastructure, the gap between engineering education and professional expectations is widening. In addition, although accreditation processes aim to standardize quality, the lack of equal opportunities and capabilities among institutions further exacerbates this situation. In order to address these problems, the implementation of competency-based education and systematic capacity development studies are necessary. Thus, by increasing the cooperation between universities and public institutions and industrial organizations in Türkiye, by improving laboratory and field education and by adopting practical learning methodologies, qualified engineering graduates who can meet both national and international demands can be trained.

Strengthening vocational education and training has become primary policy areas in the educational policy priorities of many countries today (Jeon, 2019). Capacity building, now also referred to as capability building, not only incorporates such transformation of institutional or program structures but also holds a holistic approach toward developing the competencies and skills of individuals and organizations in knowledge, skills and competencies (Brockmann et al., 2008). This process concentrates on continuing improvement and up scaling of talent of the stakeholders in the education system to achieve sustainable results such as students, academics, employers, and decision makers (Whelan et al., 2024). Capacity building serves the purpose of creating a dynamic learning ecosystem that will quickly adapt to the new technological advances, changing labor force needs and global standards. Therefore, capacity building (also known as capacity development) or capability building is concerned with the sustainable empowerment of institutions and individuals in knowledge, skill, and ability (Lusthaus, 1999). Its impact in relation to the context of vocational and technical education is embedded in the CB VET (capacity building in vocational education and training) approach. CB VET proposes revising curricula to fit the needs of the real-world sectors, improving the occupational competencies of trainers and managers, popularizing practical learning methods, strengthening laboratory and field infrastructures and formalizing partnerships with industry in the educational system. Thus, vocational and technical education might be seen to assure a sustainable advantage in international and national competitive contexts.

Although engineering education in Türkiye has a historically solid foundation in science and mathematics (Birgül Tantekin et al, 2004), it has been voicing concerns for many years about applied and industrial experience (Özsoy, 2013). Criticism points out the fact that students in different engineering departments have had quite a few compulsory courses with their peers but have not acquired some neccessary skills such as problem-solving and communication skills or innovation and entrepreneurship after graduation (EMO, 2012). For example, it is a notable area of concern that such important topics as consultancy and advisory services in the field do not appear at all in academic curriculum or are presented too superficially. That adds to the disconnection between what is expected in industry and what is offered by universities. Furthermore, in that direction it contributes to diversity in the levels of knowledge and skills of graduates due to the significant infrastructure differences between engineering departments across the country (such as laboratory facilities, internships and field practices, faculty-staff-student ratios, and so forth) (Özsoy, 2013). On the other hand, the low salaries offered recently by the private sector from graduation onwards and the lack of career satisfaction of young engineers is another major problem (Koyuncuoğlu, 2017). This is mainly due to frequent complaints from employers that graduates are mostly equipped with theoretical knowledge, but not enough knowledge about field practices, new engineering technologies, project management approaches or the entrepreneurial ecosystem.

According to current Higher Education Council (in Turkish Yüksek Öğretim Kurumu - YÖK) data (YÖK Atlas, 2025), there are 74 Environmental Engineering undergraduate programs in different universities in Türkiye. Some of these programs are accredited by Association for the Evaluation and

Accreditation of Engineering Programs (MÜDEK) or have been internationally accredited by Accreditation Board for Engineering and Technology (ABET). Accreditation is seen as evidence that the education program will meet some quality standards and will provide students with "learning outcome based", "hands-on", and "employability-focused" experience (Özçiçek and Karaca, 2019). Therefore, the aspects of capacity building in terms of such as MÜDEK and ABET accreditation processes should be important tools in continuous renewal and complementing the missing ones within institutions (Ergin et al., 2023). However, between the departments of environmental engineering in Türkiye, there are many differences both in the content of the lectures and also in laboratory and field applications. Some universities emphasize compulsory general and vocational courses, while others offer specific elective courses such as air pollution control technologies, climate change, solid waste recovery, sustainability and membrane processes. In universities with a very heavy classical education load, there are insufficient courses on “current” or “business-oriented” skills such as creativity and entrepreneurship, and little emphasis on practical training. As a result, the majority of graduates enter the labor market directly into the labor market ill-equipped with the basics of consultancy and advisory services, project management and financing, or even very basic skills such as effective communication and leadership skills.

Capacity-building approach, which is a model aimed at continuously improving the capacities of educational institutions and individuals (Malyan and Jindal, 2014), assumes a very critical position with respect to environmental engineering education. The CB VET approach requires constant updating in engineering departments, from the curriculum to the sector and current needs (Agamuthu and Hansen, 2007). Some of these updates are presented below,

- Increasing the professional competencies of educators and administrators;
- Equipping students not only with technical knowledge but also with entrepreneurial skills, innovation, project management, and leadership when they graduate;
- Improving laboratory and field training infrastructure through university-industry collaboration projects;
- Improving acknowledgment (MÜDEK, ABET, etc.) processes to be seen as a chance and introducing continuous improvement mechanisms.

The model of CB VET creates a detailed sketch for the improvement of quality and relevance of vocational education in areas like Environmental Engineering, as shown in Figure 1. It operates through four key pillars: laboratory infrastructure, academic staff development, applied courses and stakeholder engagement. These items are bound to address the existing gaps in institutional capacity, practical training opportunities and match with industry demands. Laboratory infrastructure takes a predominant role in establishing practical learning environments, accreditation processes and field experience acquired by the students. Continuous professional and specialization development is what academic staff development signifies; it ensures an educator's competency in curriculum delivery, which is up to date and relates to the industry. Applied courses help in enhancing the skills of the students through project-based learning as well as field learning activities, and stakeholder engagement encourages working with industry, government, and other organizations involved in creating a fully aligned program according to the market. This is a system approach based on principles of competence-based education; it leads to sustainability, interdisciplinary learning, and collaboration among various stakeholders so that graduates can address key problems faced in the newly formed world such as climate change, strategies for circular economy operations, and sustainable development. In synthesizing all these elements into one comprehensive picture, the CB VET model has created a context that will allow countries to develop highly skilled and flexible manpower attuned to both national and international quality standards.

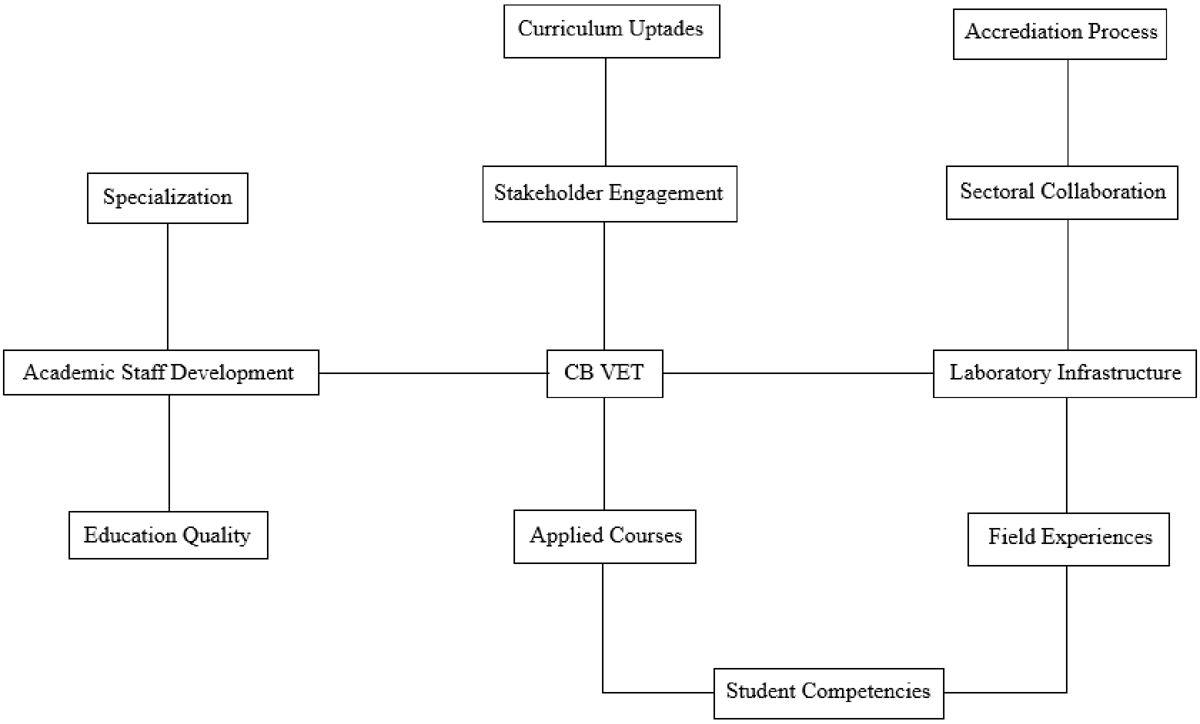

Figure 1. Building blocks of the CB VET model and engineering education.

The main objective of this research is to analyze the setting of the environmental engineering education in Türkiye through the CB VET approach derived from capacity building perspective and post suggestions for improving the program's quality, implementation capacity, and sectoral linkages. The paper will first cover the state of engineering in general, and Environmental Engineering in particular, in Türkiye; it will then discuss problems observed at educational institutions (curriculum not being matched to actual professional practices, not enough on consultancy and advisory service provision, lack of courses that improve entrepreneurial and innovative skills, lack of overload on courses, etc.). How capacity building opportunities provided by MÜDEK and ABET accreditations can be converted into added value will also be examined in this process. Finally, concrete contributions will be made to the solutions that can be proposed through CB VET and applicable strategies for a much more qualified and competitive environmental engineering education. In addition, the study, which aims to illuminate the improvement of quality and accreditation processes in engineering faculties, provides a reference framework for stakeholders who aim to strengthen vocational and technical education. Especially in today's conditions, it is becoming increasingly important to include the rapid development of virtual reality, augmented reality and artificial intelligence into the curricula of engineering departments. In addition, the increasing impact of environmental problems and the climate crisis will require a comprehensive review of Environmental Engineering education with a capacity-building approach.

Method

Data Collection Process

This study used a qualitative research design using document analysis and informal interviews with industry representatives to examine environmental engineering programs in Türkiye within the framework of the CB VET approach. Primary data sources included printed and online documents such as course plans, program quotas, accreditation standards and reports published by MÜDEK and ABET, Vocational Qualifications Authority (in Turkish Mesleki Yeterlilik Kurumu-MYK) regulations, and various strategic plans, quality assurance reports, and accreditation self-assessment documents available on university websites. In addition, informal interviews were conducted with graduates and professionals from engineering firms to gain insight into the practical challenges faced by graduates and the fit between university curricula and industry needs. Secondary data sources such as national and international academic articles, conference proceedings, industry reports, and capacity building project reports funded by the European Union (e.g. Erasmus+ and IPA) were also analyzed to provide a comprehensive understanding of the research problem. Document analysis method was applied to systematically review and categorize program information and curricula for the last five years, thus ensuring timeliness and reliability in the findings of the study.

Data analysis

A content analysis was conducted on the collected data. The study focused on the main themes of the departments' curriculum structures (mandatory/elective courses, applied courses, credit distribution), practical training opportunities (laboratories, internships, field studies, project-based courses), and competency-based education practices (entrepreneurship, leadership, innovation, communication, and project management skills). The impact of accreditation processes (MÜDEK and ABET) on education quality was also examined, and a comparative review of differences between institutions was conducted. While the document analysis provided structured insights, informal interviews with graduates and industry representatives over a period of two years helped contextualize the findings. Thus, the study bridged the gap between formal education policies and real-world industry expectations. These interviews revealed both the professional problems experienced by environmental engineering graduates in business life and identified employers' industry concerns regarding the competencies of these graduates. However, given the informal nature of these discussions, they were not transcribed verbatim, but instead were used to identify recurring themes and industry expectations. Since this study is mainly based on secondary data and informal qualitative insights, no formal surveys or structured interviews were conducted. The data collected are presented in the following sections under the main themes of CB VET principles, the general structure of Environmental Engineering education in Türkiye and the contribution of accreditation processes, aiming to provide a general framework on the scope of educational programs, practical educational integration and the current status of competency-based educational approaches.

Findings

The results obtained from the analysis on the confront of CB VET and competence based vocational education perspective of the Environmental Engineering undergraduate programs in Türkiye are discussed in discussion holistically. The study analyzed the university curricula, academic staff structures, laboratory and field infrastructures, accreditation (such as MÜDEK and ABET) processes, international funds and project mechanisms, sector and graduate feedback, and literatures "competence-based VET" principles. The analysis indicates that environmental engineering programs had to cope with structural and institutional challenges demanded by competence-based education in providing required practical and interdisciplinary experience. Under the following headings, causes, consequences and recommendations to overcome these challenges are discussed. The fact that environmental engineering departments, especially in the eastern and central Anatolian regions, are closed to undergraduate education or are less preferred may also be an opportunity for the transformation of these departments. On the other hand, the gradual decrease in the success scores of students who are accepted to environmental engineering undergraduate programs, as in other engineering departments, is another important problem that needs to be solved within the higher education system in Türkiye.

Alignment between Curriculum Design and Competency-Based Education

VET envisages that students acquire not only theoretical knowledge but also somehow 'horizontal competencies', skills of applications, problem solving, collaborative effort and communication (Inayat et al., 2013). However, when the curriculum of Environmental Engineering departments in Türkiye is analyzed, it is seen that it revolves around compulsory science-mathematics based courses in addition to classical engineering courses (water and wastewater treatment, air pollution control, solid waste management, etc.) (Sarıoğlu-Cebeci and Yılmaz, 2014). This describes a good academic base. However, it shows how existing practice-oriented courses such as “waste recycling and management”, “hazardous waste disposal”, “noise pollution and control”, “air pollution modeling” have different depths across universities. Table 1 lists the courses included in the environmental engineering curriculum of universities. While the courses included in this table are offered in the elective course pool in some universities, these courses are either not included at all or are offered as a general course in other universities. Some of the reasons that make this situation more evident in certain professional courses are the faulty departmental structures in terms of low institutional capacity (low competence of staff and inadequate laboratory/field infrastructures) and insufficient staff (non-specialist staff managing the relevant departments). The competency-based VET approach requires both theory and practice to be integrated into a course structure and also requires students to encounter and solve real-world industrial or public problems (Azemikhah, 2005). This should be combined with the availability of specialized academics to conduct the relevant courses practically, as well as all the equipped laboratory-field conditions they need for this approach to function effectively. These shortcomings above lead to a weakening of the professional skills of graduates and a further mismatch of education with the world of work. The lack of consultation with sector representatives in the development of education and training plans and curricula is another obstacle to the widespread adoption of competency-based education. The sector has knowledge about the nature and degree of difficulty of the problems that graduates will face in real working life and can provide invaluable input on how to adapt course content to these problems. There is also a need to establish important feedback mechanisms for continuous updating and improvement of the curriculum (Davis, 2008), and to regularly analyze alumni and employer feedback and student satisfaction survey results. The data from these studies will provide invaluable information on how to adapt course content to current problems. Important feedback mechanisms for continuously updating and improving the curriculum will also be the regular analysis of alumni feedback and student satisfaction survey results. This feedback will show to what extent the expectations of both students and the sector are met for these courses. In addition, it is necessary to increase the number of courses that will ensure active participation of students through projects and to update the equipment used in these courses. Universities can make practical training in the laboratory or field mandatory and regularly evaluate the feedback from the relevant sector to ensure the continuity of these trainings. In this way, students have the opportunity to put their theoretical knowledge into practice and step into the labor market more prepared.

Table 1. Courses and Classification of Environmental Engineering Departments (Sarıoğlu-Cebeci and Yılmaz, 2014)

Basic Courses	Vocational Courses	Construction-Geology Courses
Mathematics	Environmental Economics	Thermodynamics
Physics	Introduction to Environmental Engineering	Fluid Mechanics
Chemistry	Environmental Ecology	Hydrogeology
Technical Drawing	Environmental Chemistry	Geostatistics
Basic Information Technologies	Environmental Problems	Statics and Strength
Differential Equations	Environmental Microbiology	Surveying Materials
Statistics	Environmental Pollution	Hydraulics
Basic Computer Science	Control Solid Wastes	Soil Mechanics
Engineering Mathematics	Environmental Impact Assessment	Hydrology
Computer Aided Drawing	Environmental Law	Structural Engineering
etc.	Water Supply and Disposal	Geology
	Water Quality and Control	etc.
	Hazardous Wastes	
	Air Pollution and Control	
	Environmental Modeling	
	Soil Pollution and Control	
	Environmental Management	
	Urbanism and Regional Planning	
	Groundwater Pollution	
	Noise Pollution and Control	
	etc.	

Table 1. Courses and Classification of Environmental Engineering Departments (Sarıoğlu-Cebeci and Yılmaz, 2014) (Continued)

Treatment Focused Lessons	Social Lessons	Elective Courses
Basic Processes (Physical, Chemical and Biological) Fundamentals of Treatment Treatment Plant Design Operation of Treatment Plants Wastewater Engineering Treatment of Drinking Water Treatment of Wastewater Treatment of Industrial Wastewater Treatment Sludges Anaerobic Treatment Sea Discharges etc.	History of Atatürk's Principles and Reforms Turkish Language Foreign Language Other social courses offered by the University	Elective courses offered by the university and department

The Critical Role of Hands-On Training and Field Experience

In the competency-based vocational education approach, learning is expected to take place primarily in “real-life contexts outside.” Environmental engineering is a field where it is very difficult to gain sufficient expertise through laboratory and field experience, especially in the areas of solid/hazardous waste management, air and noise pollution monitoring, and wastewater treatment process optimization. Therefore, it is very important for the institutions with ABET and/or MÜDEK accreditation among the universities examined to spread the internships over two semesters (2 x 20 working days, etc.), make project-based courses mandatory, and add field trips to the program. For example, in the air pollution control course, students are expected to make measurements with real instruments, to make noise measurements in accordance with the relevant standards, to make technical observations in solid waste recycling facilities, to prepare and present Environmental Impact Assessment reports through group work, to report the measurement results in accordance with field experience, and to prepare their projects in the format they should be in business life, which will better prepare students to face the problems they will encounter in the field when they graduate. Another important issue is that in accredited departments, students do laboratory and field practices in small groups with fewer people rather than with the whole class, and they have the opportunity to observe better and even conduct experiments themselves. In addition, in accredited departments, quizzes before experiments and student reports after experiments are clear indicators of what the relevant course adds to the student. In other words, it has been observed that practical training is more limited in non-accredited programs. Although field trips or project-based topics are included in the curriculum, it is also a fact that these are limited in practice in universities where specialized faculty members and laboratory infrastructure are weak. this leads to students graduating with less knowledge and experience and entering business life. On the other hand, “network-based” learning in higher education, where universities, private sector firms and public institutions carry out applied projects through a strong network of cooperation, has not yet taken an institutional or systematic shape in Türkiye. A schematic representation of this ideal structure for competency-based vocational education and training in universities is presented in Figure 2.

As illustrated in Figure 2, in order to improve environmental engineering education, first of all, an approach that eliminates the deficiencies in the current system should be adopted. As seen in the figure, the integration of three main components (field education, accreditation and network-based learning) is important to achieve the ideal situation in education. By increasing the interaction between field education and accreditation, students can be enabled to put their theoretical knowledge into practice. Supporting this interaction with more collaboration and network connections will provide students with the ability to cope with real-world problems. In addition, the accreditation process should be constantly reviewed in terms of the compliance of educational programs with quality standards. Finally, strengthening the network-based learning infrastructure will create an environment that will enable students to follow global developments and learn innovations in the field of environmental engineering. In this way, environmental engineering education can be made more competitive and suitable for the labor market both locally and internationally.

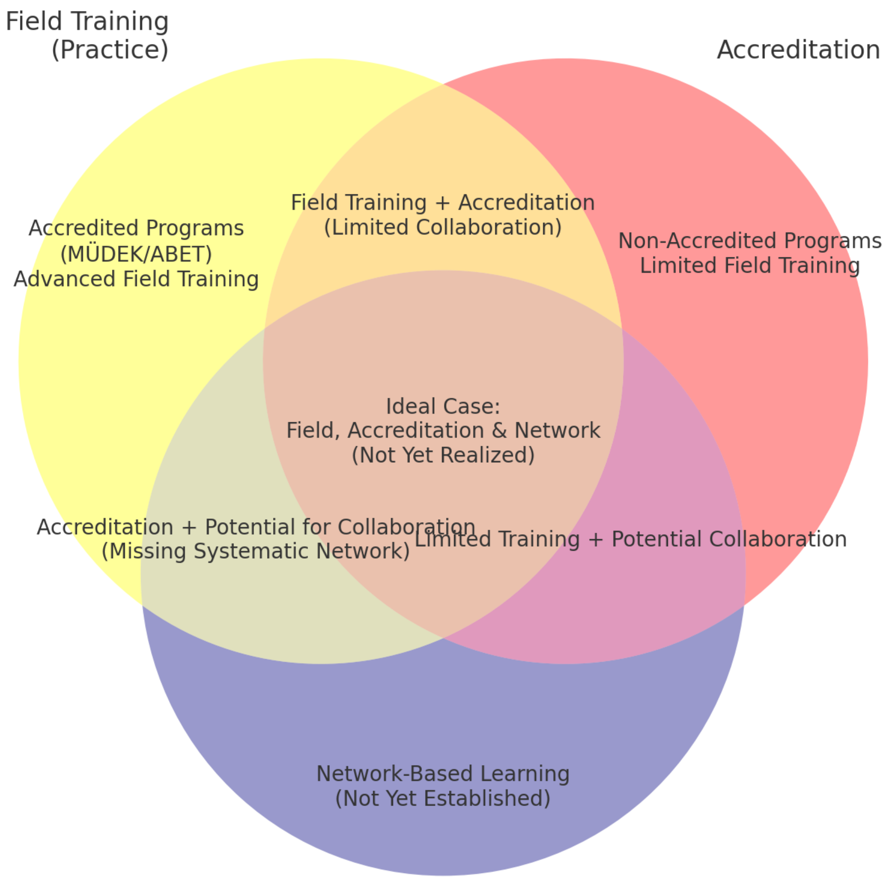

Figure 2. A schematic representation of competency-based vocational education and training in Türkiye.

Contribution of 7+1 Education Model

The new 7+1 education model that started to be implemented in some universities in Türkiye with engineering faculties is an important opportunity for increasing applied education and field experience (Özsoy, 2013; Yavuz, 2019). This model is designed to have one of eight semesters of undergraduate education spent full-time and integrated with industry to strongly network students with the sector (Özsoy, 2013). Therefore, the students who had taught theoretical and applied courses in the first seven semesters, will strengthen their professional competencies with one term of on-the-job experience within real projects in the eighth semester. This active involvement of industry representatives would facilitate students to develop multiple competencies related to workplace problem-solving, teamwork, corporate communication like multidimensional competencies well before they actually graduate. Therefore, this 7+1 model will be seen as an appropriate "shaping and networking" strategy for the approach of competence-based VET. Especially in department such environmental engineering that require a great deal of field experience, this 7+1 model will serve as a bridge between learning in laboratories and in the field and adaptation to the job market. The wider adoption of this model in each university would also allow quicker reflection of sector feedback on course contents and improve competitive advantages at the labor market for the graduates. In this new model, students will reinforce the subjects they have learned in their workplaces and work in real conditions, which will increase their adaptation to the job market and their success after graduation.

Department Structure and Distribution of Faculty Members

Within environmental engineering programs, basic science majors such as “air pollution and control” and “solid waste management” will generally reflect the disciplines of the field. However, the examination of the CVs of academic staff on department websites and open sources within the scope of this study revealed that errors were made in personnel planning based on departments in some universities. For example, while academics who do not have expertise in air pollution may be assigned to the “air pollution and control” major in some universities, it was observed that some academics who do not have experience in “solid waste management” were employed in these fields. Employment of personnel outside the field of expertise in departments causes curricula to narrow, specific courses requiring expertise to not be opened, efficiency in applied training decreases and ultimately the quality of education and training decreases. Naturally, this means that the expectations of stakeholders in the public and private sectors from graduates cannot be met. This situation draws a picture that is exactly the opposite of the principle of “subject-specific applied experience, expertise and direction”, which is the essence of the Competency-Based Vocational Education approach. Figure 3 shows an example of an ideal department organization (Lane Community College, 2025). As can be understood from this graph, the strengths of the program, opportunities for improvement, expectations, outputs (program-specific outputs and indicators), peer evaluation feedback and in-depth evaluation of program improvement suggestions are very important for the structuring of the department. However, it is the academic staff employed in the departments who should do all of these. As a result, making mistakes in personnel selection causes the entire structure to fail.

Another important problem encountered in some universities is that the department's infrastructure planning is not done by academicians who are experts in the relevant field or that sufficient budget is not allocated for any reason. Incorrect decisions made by academicians who can be assigned from outside the field can reduce the department's infrastructure and field research potential. As a result, for example, the incorrect selection of noise pollution measurement devices by people who do not have practical experience will cause courses to be limited to theoretical frameworks most of the time and the necessary applications and reports will not be fully done. The inadequacy of the department's machinery and equipment will also cause students to be inadequate in engineering practices. In addition, priority investments in laboratory budgets and budgets allocated for instrumentation and software infrastructures of these departments are postponed and they do not have the opportunity to develop capacity. Finally, the "personnel plan" problem will cause the enrichment of the curriculum with competency-based courses to be postponed and will further distance students from the field of practice. Therefore, it may be very important to obtain opinions from relevant stakeholders in the structuring of engineering departments. Professionals working in the fields of air pollution, noise pollution, and hazardous waste management can help identify the areas of expertise that are urgently needed, as well as the subjects in which students are lacking. In addition, the opinions of alumni and student satisfaction surveys will provide guidance on staff adequacy, the efficiency of courses and up-to-dateness of the curriculum.

Figure 3. Department planning framework

As understood from Figure 3 (Lane Community College, 2025), strategic planning and management should be established to increase the quality of professional education in environmental engineering programs in Türkiye. With the adoption of this approach, opportunities for quality education will be accessible and the concept of education will become student-centered. Departmental planning should be designed to maximize individual student success. Programs should equip students with the knowledge and skills to address the problems they will encounter in the job market in the field of environmental engineering. Student success should be the focus of the program and quality learning environment, access to learning opportunities and stakeholder participation should be the main themes. Further improvement of the quality of laboratories, field studies and other learning tools is vital for achieving sustainable development. Under strategic orientations and priorities, environmental engineering departments should continuously review their programs, identify strengths, opportunities and disadvantages and produce solutions for them. Monitoring of educational programs, data analysis of effectiveness, collection of student and industry feedback and updating educational strategies based on these will also fall into the category of this strategic orientation and goals. Environmental engineering departments should also ensure maximum resource allocation to laboratory and field education facilities in their strategic approaches to strengthening educational infrastructure. This will move environmental engineering departments to a more competitive and industry-relevant status and increase the quality and employability of graduates in the labour market. In this context, program accreditations such as ABET and MÜDEK provide a roadmap for these departments.

Accreditation Processes, Importance of Sector and Alumni Participation

In Türkiye, MÜDEK and ABET accreditations are strong and important mechanisms that establish the "continuous improvement" and "stakeholder participation" cycle for environmental engineering programs (Engin et al., 2023; MÜDEK, 2023; Taşçı and Lapçın, 2023). Accredited programs are expected to design curricula according to learning outcomes; increase the proportion of practical courses; and regularly update curricula using feedback from engineering companies, public institutions, and alumni (ABET, 2025). Therefore, accreditation criteria mostly coincide with the goal of "equipping students with various skills (Shuman et al., 2005)", which is at the core of the Competency-Based Vocational Education and Training approach. In addition, both CB Vocational Education and Training and accreditation processes are based on a competency-based framework and emphasize continuous improvement and stakeholder participation. And, international funding and project calls (e.g. Erasmus+, IPA projects, etc.) have the potential to provide additional resources and technical expertise for capacity building initiatives. Universities could possibly fund projects such as providing laboratory equipment for hazardous and non-hazardous waste, soil pollution, air pollution, noise pollution and other field-specific courses, practical training for faculty members and participation in international training programmes. However, for these projects to yield productive results, they are highly dependent on the participation of sector representatives (public, private and NGOs) and alumni in the curriculum development process. Regular alumni surveys, student satisfaction measurements and feedback from industry will further identify gaps in education to facilitate the effective use of funds and to form the basis for robust accreditation processes in the future. The problems that students will face after graduation and the competencies they need to address these problems should be determined in close collaboration with the industry and integrated into the curriculum. Industry representatives should help universities shape their educational content by determining what skills they expect graduates to have in the labor market. In addition, a monitoring and evaluation system that includes student and industry feedback should be established. In this way, programs can be brought closer to the industry, increasing the employability of environmental engineering graduates.

Competence-based Shaping, Networking and Recommendations

The success of the competency-based vocational education model is based on the principles of "shaping" (shaping the dimensions of students with rich skills) and "networking" (increasing real-life learning opportunities by creating common networks with stakeholders) (Bohne et al., 2017). Environmental engineering departments in Türkiye need to focus on the following points to progress in this perspective:

- Academic staff and department structures should be re-evaluated.
- The curriculum needs to be restructured to ensure theory-practice balance.
- Laboratory and field infrastructures should be improved.
- Effective use of financial resources, including non-university project resources, should be ensured.
- A quality assurance system based on continuous improvement and stakeholder participation should be established.
- The industrial experiences of faculty members should be continuously developed.
- Priority should be given to the student-centered approach.
- The classical environmental technology and environmental sciences department structure should be abandoned and a specialization-oriented department structure such as water and wastewater treatment, soil pollution and solid waste control, air pollution control and climate change should be implemented.

Future Perspective: Digital Transformation in Education

International environmental policies and global agendas are showing a very rapid development rate in subjects such as climate change, circular economy and digitalization. Environmental engineering education should be updated to protect this new paradigm in sustainable technologies and holistic management approaches. Preparing digital subjects such as "waste recycling for circular economy", "smart sensor technologies" or "pollution monitoring with remote sensing technologies" as courses and presenting them through sectoral collaborations will ensure that Competency-Based Vocational

Education and Training is well aligned with the demands of the time. Such improved courses should also integrate technologies such as augmented reality (AR) and virtual reality (VR) into the learning model, which will provide a more effective dissemination of theoretical knowledge as well as equip students to develop practical application skills primarily through student practice (Mwaura, 2024; Ghazali et al., 2024; Soliman et al., 2021). The formation of virtual laboratory environments with the help of VR technologies allows students to learn through direct experience on complex processes (Soliman et al., 2021). Besides, AI-based learning tools may offer personalized learning pathways. These types of innovative approaches will ensure that students are quick to prepare for the applications of future environmental engineering. At this juncture, opinions of representatives of industries in addition to alumni and students provide valuable insights into the answers to questions such as which technologies are spreading faster and where additional skills are needed. Therefore, shaping educational plans, academic staff appointments, and laboratory investments according to the feedback received regularly from these stakeholders will increase the competitiveness of departments. In order to increase the usability of these technologies in education, curricula need to be restructured to focus on digital skills. In particular, simulations of complex processes such as environmental engineering can be performed in virtual laboratories so that students can experience various scenarios. In addition, thanks to these digital technologies, students can learn about innovative applications and technologies in environmental engineering. This transformation will not only teach students the basics of environmental engineering, but will also make them better equipped for future workforce needs.

Discussion, Conclusion and Suggestions

From this holistic study, it appears that Environmental Engineering programs in Türkiye can evolve into a fully equipped, practice and innovation-oriented education model as envisaged by Competency-Based VET. However, multidimensional improvements are needed at both institutional (in terms of curriculum, laboratory facilities, accreditation, strategic planning) and personal level (faculty expertise, continuous professional development and student field experiences). Addressing these phenomena at the national level through educational policies and taking advantage of international funding opportunities and projects can accelerate this evolution. Stakeholder feedback, especially from industry representatives, alumni and students, should be regularly mentioned as an important aspect of new curriculum development and revision. Data collected from such organizations can provide important insights into areas that require specialized faculty, courses that need to add practical components, and better ways to improve students' field experiences. Feedback mechanisms such as student satisfaction surveys, alumni surveys and industry advisory boards can serve as the most important engines for institutionalizing competency-based education and CB VET principles in educational institutions. In this context, models such as the "7+1 education model," which offers students extended interaction with the professional world, emerge as concrete implementations of CB VET. This model allows students to apply theoretical knowledge in real-world work environments during a dedicated internship period, effectively bridging the gap between academic preparation and professional practice.

When YÖK Atlas is examined, it is seen that there are differences between environmental engineering programs in terms of the number of students and minimum entrance scores. There are also significant differences in academic performance, laboratory infrastructures and research facilities in the departments of different universities. In these respects, improvements should be made to increase the capacity and quality of education in universities. CB VET emphasizes that environmental engineering departments should not only improve existing course content, but also include a holistic curriculum approach that includes improving laboratory and field infrastructure, increasing faculty members' industry experience, and institutionalizing stakeholder engagement. The curriculum should also be aligned with real-life issues such as waste management, air pollution control, climate change adaptation and circular economy, which will prepare graduates well to meet current environmental challenges. In engineering departments, accreditation (e.g. MÜDEK, ABET) and external grants are crucial for capacity building. CB VET recognizes possible opportunities for training of academic staff, renewal of laboratory infrastructure and the creation of a wider network of industry-university cooperation. Through the continuous improvement cycle and quality assurance strategy, environmental engineering departments will become an important program that increases the employability and career opportunities of its graduates and contributes to solving very complex environmental problems.

Environmental engineering education in Türkiye needs to be transformed into a competency-based, field practice-based and stakeholder-oriented system. Moreover, given the increasingly complex nature of environmental problems and global competition, it is essential for Turkish universities to compete with universities in developed countries. The implementation of competency-based educational principles, coupled with a robust stakeholder management plan and effective quality assurance, will result in environmental engineering graduates as skilled, internationally recognized professionals with experience in the field, analytical thinking skills and innovative ways of solving complex problems. This transformation will strengthen the position of graduates in the labor market, increase the quality of solutions to Türkiye's environmental problems, and bring Türkiye closer to its sustainable development goals by both solving problems and producing environmental technologies.

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