Is the Education in Standardization One of the Best Approaches in Training the Next Generation of Experts?

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Abstract

The growing complexity and globalization of industries highlight the crucial role of standardization in ensuring quality, interoperability, and innovation across sectors. Europe needs the best standardization experts to pursue its global standard-setting ambitions to safeguard a digital, green and resilient single market. As industries evolve, the demand for experts well-versed in standards and their implementation becomes increasingly urgent.

The strategic importance of standards requires more attention and promotion. Students do not often get the value of learning about standardization until a later stage of their career. At the same time, the industry, public authorities, and societal stakeholders need experts to assist them in the standardization process. Increasing the incentives for students and universities to engage in

standardization depends on market attractiveness and societal perspective on standardization This paper presents an example of best practice of collaboration between national standardization bodies of Romania, Bulgaria, Universitat Politècnica de València, Spain and University of Life Sciences "King Mihai I" from Timisoara, Romania in developing micro-credential courses. This paper investigates whether the integration of standardization into educational frameworks represents a new and necessary vision for developing the next generation of experts.

Keywords: higher education, curricula, standardization, research, quality assurance.

1. Introduction

In an increasingly globalized and interconnected world, standardization plays a key role in ensuring the interoperability, quality and safety of products and services. Standards provide the framework for industries to operate effectively, facilitating international trade, innovation and competitiveness in global markets. In particular, the European Union (EU) relies on standards to support its ambitions for a digital, green and resilient single market. These standards are essential to ensure a sustainable transition to a green and digital economy, but their success crucially depends on the knowledge and skills of the workforce (Bakhouyi et al., 2017; Balan & Tulcan, 2013; De Vries & Egyedi, 2007; De Vires et al., 2010).

However, despite the obvious importance of the standards, education in this area is often neglected in traditional academic programs. Students often encounter standardization concepts only later in their careers, often in the context of specific job requirements. This lack of early formal education in standardization contributes to a skills gap between market demands and graduate training. As industries rapidly evolve under the pressure of technological innovation, climate change and international regulations, it becomes increasingly urgent to develop well-trained experts who understand and implement these standards (Fiofanova, 2021; Ionescu et al., 2020; National Research Council, Board on Science Education, & Committee on Guidance on Implementing the Next Generation Science Standards, 2015).

In this context, education in standardization becomes not only relevant, but essential. Integrating

standardization into the university curriculum can have a significant impact on training the next generaon of experts. From ensuring quality and regulatory compliance, to supporting innovation and international collaboration, education in standardization can equip future professionals with the skills to navigate a dynamic and competitive global environment. At the same time, students who acquire a solid knowledge of standards are better prepared to meet the challenges of sustainability, safety and efficiency in various economic sectors (Plakhotnik et al.. 2023; Puiu S, 2020).

An example of efforts to integrate standardization education in higher education is the European B-Green-ED project, carried out within the Erasmus+ Program. The project involves collaboration between renowned universities from four European countries: Bulgaria, Spain, Romania and Lithuania, together with national standardization bodies from Romania (ASRO) and Bulgaria (BDS). The project's main aim is to develop innovative micro-credentials that meet the demands of the labor market and support the transition to a green and digital economy. These micro-credentials were designed to provide students and professionals with the opportunity to gain specialized knowledge in critical areas such as carbon footprint assessment, quality management, and bioeconomy. The micro-credential courses have been structured to be flexible, accessible and adapted to the needs of the market, allowing participants to acquire relevant skills in a short period of time, but with a significant impact on their career. The B-Green-ED project thus represented an innovative initiative to integrate standardization in education, meeting both the needs of students and industry (Boosting the green future via university micro-credentials /B-GREEN-ED).

This paper aims to analyze the impact of this initiative on the education and training of the next generation of standardization experts. We will focus on evaluating the results obtained in the pilot courses of the B-Green-ED project and explore how these micro-credentials can contribute to the development of a new educational model focused on standardization. We will analyze the relevance of this educational model for various industries and discuss the benefits and challenges of its implementation in the European and international context.

2. Material and Methods

2.1 Project context

The present study is based on the activities and results of the B-Green-ED project, carried out under the auspices of the Erasmus+ program (KA 220 – Higher Education). This project was coordinated by an international consortium of four universities and two standardization bodies. The main goal of the project was to develop and pilot micro-credentials oriented towards ecological standards and sustainability management, thus addressing the challenges of the transition to a green and digital economy in Europe (Boosting the green future via university micro-credentials /B-GREEN-ED).

The consortium involved the following institutions: Bulgaria- Burgas Free University (BFU) - project coordinator and Bulgarian Institute of Standardization (BDS), Spain- Polytechnic University of Valencia (UPV), Romania - University of Life Sciences"King Mihai I" from Timişoara (USVT) and Romanian Standardization Association (ASRO), Lithuania- Mykolas Romeris University (MRU).

2.2 Purpose and objectives of the study

The main objective of the B-Green-ED project was to support the transition to a European green economy by developing innovative educational practices that include standardization in higher education programs. Through micro credentials, the project aimed to provide students and professionals with the opportunity to acquire specific skills in highly standardized areas such as carbon footprint assessment, bioeconomy risk management, circular economy, environmental and management systems (Boosting the green future via university micro-credentials /B-GREEN-ED).

This study investigates the methodologies used within the project to develop, implement and evaluate these micro-credentials. In addition, we aim to analyze how these courses have contributed to the formation of relevant skills for the labor market and the creation of a workforce prepared for future challenges.

2.3 Development and implementation of micro-credentials

Within the B-Green-ED project, 12 micro-credential courses were developed and piloted, organized by the four partner universities. Desk research on the current state regarding the

provision of training on standards, turned out a proposal of 15 areas of interest for standards learning, grouped in 6 domains, in accordance with the opinions of the experts interviewed, who are active in these fields. The two national standardization bodies, BDS and ASRO, made a research and analysis of European and International standards in the defined areas and domains and proposed 153 standards among which universities have chosen 46 standards to develop the micro-credential courses.

These courses have been structured to cover relevant areas from a standardization and green economy perspective. The **Table 1** shows the titles of the courses implemented in each of the partner countries:

University	Course Title	Standards
BFU (Bulgaria)	*Circular Economy business models and green standards*	CLC/TR 45550:2020, EN 45555:2019, EN ISO 14006:2020, 45554:2020
	Electronics and Communication of Renewable Energy Sources – green standards	EN ISO/IEC 13273-2:2015, EN ISO 50001:2018, EN IEC 62934:2021
	Engineering and Exploitation of Energy Systems – green standards	EN ISO 50001:2018, EN IEC 62933-1:2018, EN ISO/IEC 13273-2:2015
UPV (Spain)	Quality management system standards	ISO 9000:2015, ISO 9001:2015, ISO 9004:2018, ISO 10006:2017, ISO 10007:2007, ISO 18091:2019
	Environmental Management Systems standards	ISO 14001:2015, ISO 14004:2016, ISO 14006:2011, ISO 14031:2013, ISO 14040:2006, ISO 14044:2006
	Waste Management and Industrial Pollution control standards	ISO 24161:2022, ISO 15270:2008, ISO 18601:2013, ISO 18602:2013, ISO 14064-1:2018
USVT (Romania)	Risk management in the bioeconomy	ISO 31000:2018, ISO 31073:2022, IEC 31010:2019, EN IEC 31010:2019, IWA 31:2020, EN ISO 22005:2007
	Carbon footprint assessment	IWA 42:2022, EN ISO 14067: 2018, EN ISO 22526-1:2021, EN ISO 14090:2019, EN ISO 14091:2021
	Biomass and Good Practices in the Management of Degraded and Desertified Lands	EN ISO 17225- 1:2021, ISO 17828:2015, BS EN ISO 18135:2017
MRU (Lithuania)	Andragogic technologies and safe environment	EN ISO 56000:2021, EN ISO 21001:2018, EN ISO 14040:2006,
	Social responsibility and career management	ISO 26000:2010, ISO 21500:2021, ISO 31073:2022, EN ISO 14001:2015
	Social responsibility in family work	ISO 26000:2010, IWA 34:2021

Table 1. Micro-credential courses implemented in the partner countries' universities
Source: Boosting the green future via university micro-credentials /B-GREEN-ED

All micro-credentials have been designed based on a standardized framework, following EU training and certification guidelines (Carțiș A et al.). This framework included essential elements such as learning outcomes, form of participation (online or hybrid), assessment methods and identity verification during assessments. Each course has been structured to

provide a clear set of transferable skills, useful for both students and professionals wishing to specialize in the field of standardization.

2.4 Piloting methodology

The piloting of the micro-credential courses took place over 12 months, within the framework of the international partnership. Each partner university was responsible for organizing and implementing the courses at the national level, involving students and professors from various fields. The courses were conducted online, through e-learning planorms specially developed for this project. In addition, some courses were organized in a hybrid format to facilitate access to participants from diverse geographic areas.

To assess the success of implementation, each partner collected data from participants using satisfaction questionnaires and semi-structured interviews. These questionnaires were structured in three sections:

1. **Course structure and feasibility**– Evaluation of course design and clarity of educational materials.
2. **Relevance and viability of courses**– Evaluation of the relevance of the topics covered for the needs of the labor market.
3. **The quality and efficiency of the courses**– Evaluation of the quality of educational content and the effectiveness of teaching methods.

2.5 Evaluation Indicators

To measure the effectiveness of micro-credential piloting, the following qualitative and quantitative indicators were used:

Qualitative indicators: (1) relevance of courses to industry needs and labor market requirements; (2) the quality of the educational materials, according to the feedback provided by the participants; (3) student satisfaction with course structure and content; (4) effectiveness of teaching methods and transferability of acquired skills.

Quantitative indicators: (1) total number of students enrolled and attending courses; (2) percentage of students who completed courses and earned micro-credentials; (3) number of completed satisfaction questionnaires and degree of participation in end-of-course evaluations.

2.6 Data Analysis

The collected data were analyzed using descriptive statistical methods to assess the level of satisfaction of the participants and the impact of the courses on the acquired skills. The answers to the satisfaction questionnaires were centralized and compared between the partners, in order to identify possible differences in the perception and effectiveness of the courses depending on the national context. In addition, semi-structured interviews with students and faculty provided a more nuanced perspective on the challenges and successes encountered in implementing micro-credentials.

3. Results

Analyzing the data collected in the framework of the B-Green-ED project, we identified a series of determining factors that underline the effectiveness of education in standardization as a method of training the future generation of experts. In this research, multiple perspectives were examined that highlight the relevance and applicability of this approach in various industrial and educational sectors.

Our study focused on evaluating the impact of micro-credential courses, run in partnership with higher education institutions and standardization bodies, on students' professional skills. The feedback and results of the evaluations allowed the identification of eight fundamental reasons that justify the integration of education in standardization as an effective strategy for training professionals able to respond to the demands of the global market.

These reasons reflect the various benefits that standardization education can bring, not only in terms of competitiveness and operational efficiency, but also in supporting innovation, collaboration and compliance with international regulations. Next, we will present and discuss each of these reasons, analyzing their essential contribution to the development of a specialized workforce capable of operating in an increasingly complex economic and technological environment. (**Figure 1**)

3.1. Promoting global skills

Standardization education plays a key role in training the next generation of experts, particularly

due to its ability to promote global competencies. In a globalized economy, where products and services are traded and used internationally, standards provide a common basis for efficient operation and interoperability of systems. Thus, the knowledge acquired through standardization courses is not limited to a local or regional market, but has global applicability (Puiu S, 2020; Romanian Standards Association).

In the B-Green-ED project, students reported a significant improvement in their ability to understand and apply international standards. For example, they learned how to interpret European (EN) and international (ISO) standards, as well as how to implement them in a variety of industrial and geographical contexts. This competence is extremely valuable for companies operating in transnational environments, where compliance with international standards is essential to be able to access foreign markets.

Figure 1. The reasons for the integration of education in standardization in the training of future experts

Source: Original by authors

Furthermore, education in standardization not only provides students with an in-depth understanding of standards, but also prepares them to operate in diverse environments where legislation and regulations vary from country to country. This ability to navigate the various systems of standards and regulayions gives graduates a competitive advantage in the global job

market. They thus become more adapted and prepared to manage the challenges associated with international trade, global supply chains and international compliance requirements (Rosa, 2016; Tyumaseva et al., 2020).

3.2. Stimulating innovation within safe limits

Innovation is an essential component of economic and technological progress, but without clear and rigorous standards, innovation can become a chaotic, incoherent process. Standards provide a stable framework in which innovation can take place in a safe and controlled manner, ensuring that new solutions and technologies are compatible with existing regulations and quality requirements. In this sense, standardization education plays an important role in balancing creativity with regulatory compliance (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

A key aspect of the micro-credential courses piloted within the B-Green-ED project was precisely learning how standards can support innovation (Boosting the green future via university micro-credentials /B-GREEN-ED). Students were taught to identify areas in a process or technology where innovation can bring significant benefits without compromising safety, quality or regulatory compliance. For example, in areas such as bioeconomy or carbon footprint assessment, students learned how to innovate methods to reduce ecological impact while respecting international environmental standards.

Education in standardization also helps to develop critical thinking towards innovation, giving future experts a solid knowledge base on the limits and opportunities created by standards. (Comité Européen de Normalisation; Leisyte et al., 2015; Plakhotnik et al., 2023). Although standards provide clear rules and well-defined structures, they do not prevent the development of new technological solutions. On the contrary, they serve as starting points for innovative solutions that are scalable and widely applicable, thus ensuring sustainable and secure development.

Therefore, through education in standardization, students learn not only how to innovate, but also how to do so within safe and efficient limits, thereby contributing to technological progress and the development of solutions that comply with existing regulations and standards.

3.3. Quality and efficiency assurance

One of the most important aspects of education in standardization is the direct link it has with improving the quality and efficiency of processes and products (Comité Européen de Normalisation; Leisyte et al., 2015; Plakhotnik et al., 2023). In any industry, implementing standards helps increase consistency, reduce errors, and ensure compliance with local and international regulations. Students who gain knowledge of standardization are equipped to implement quality assurance processes effectively, which can have a direct impact on an organization's performance.

Through pilot courses developed in the B-Green-ED project, students learned how to apply quality management standards (e.g. ISO 9001) and specific environmental standards (ISO 14001) to optimize organizational processes. They were trained in evaluating and monitoring production and operating processes to identify weaknesses and implement corrective measures based on internationally recognized standards. Thus, education in standardization provided students with a set of tools and methodologies that directly contribute to improving the quality of products and services provided by an organization.

In addition to quality assurance, efficiency plays a central role. Standards help eliminate redundancies and optimize resources, resulting in less time, energy and money. In the project, trainees learned to identify and implement procedures that reduce waste and improve operational efficiency. This is especially essential in sectors such as the bioeconomy and waste management, where resources must be used as responsibly as possible to meet sustainability requirements.

3.4. Improving collaboration and communication

Another major benefit of standardization education is its ability to facilitate effective collaboration and communication between experts from various fields and countries. Standards act as a "common language" between industries and organizations, providing a clear set of rules and specifications that are understood and applied globally. In a world where international collaboration is increasingly common, this common language becomes essential for the success of transnational projects and initiatives (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

Through the micro-credential courses, participants in the B-Green-ED project had the

opportunity to learn how to collaborate effectively using internationally recognized standards. For example, bioeconomy students were trained to collaborate with experts from other fields, such as engineering, environment or management, using common quality and sustainability standards. This cross-disciplinary approach created a collaborative learning environment where all participants had a clear understanding of common requirements and objectives.

Moreover, standards facilitate collaboration not only between disciplines, but also between organizations and countries. In international or transnational projects, the use of common standards allows teams from different regions to work effectively together without encountering cultural or technical barriers. Thus, students who have learned to apply standards in international collaborations are better prepared to integrate into global teams and manage complex projects, regardless of the national or cultural context.

3.5. Supporting sustainability and safety

International standards play a key role in supporting sustainability and safety in all economic sectors. Through standardization education, future experts gain the knowledge to create and implement sustainable solutions that comply with environmental regulations and ensure the safety of workers, consumers and communities. These skills are becoming increasingly valuable in a global market that prioritizes the transition to a green economy (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

Within the B-Green-ED project, the pilot courses were designed to give students a solid foundation in environmental and safety standards. For example, courses on carbon footprint assessment and bioeconomy risk management provided participants with the necessary tools to assess the impact of human activities on the environment and propose measures to reduce it, while respecting international environmental standards such as would be ISO 14001.

Education in standardization enables students to understand the importance of applying rigorous safety standards in various industries, from manufacturing to construction and high technology. These standards not only protect workers and end users, but also help reduce the risks of accidents, pollution or environmental damage. Through their implementation, future experts are able to contribute to the development of sustainable solutions that comply with the safety and

environmental standards imposed by international legislation.

3.6. Preparing for regulatory compliance

Navigating a complex regulatory landscape, both nationally and internationally, is a challenge for many organizations, especially those operating in global markets. Standards provide a clear path to ensure regulatory compliance and avoid risks associated with non-compliance, such as legal sanctions, product withdrawals or reputational damage. Through standardization education, students acquire essential skills to understand and apply the standards required for compliance in various sectors (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

The B-Green-ED micro-credential courses directly addressed the issue of compliance, training students to use international standards as tools to navigate complex regulations. For example, participants in risk management and carbon footprint assessment courses learned to implement solutions that comply with European and international greenhouse gas emissions regulations. This knowledge not only prepared them to comply with legislative requirements, but also gave them the opportunity to contribute to reducing the impact on the environment.

In an ever-changing global landscape, regulatory compliance is not only a legal requirement, but also an opportunity to gain a competitive edge in the marketplace. Organizations that implement standards and comply with regulations are better positioned to access international markets and maintain a trustworthy image in the eyes of consumers and authorities. Students educated in the field of standardization understand these advantages and can apply the knowledge gained to ensure compliance of the organizations with which they will work.

3.7. Reducing costs and duplication of effort

One of the major benefits of education in standardization is the ability to reduce costs and eliminate duplication of effort within industrial and organizational processes. By adopting and implementing internationally recognized standards, organizations can avoid the high costs associated with trial and error in product and process development. Standards provide a clear and efficient framework that helps establish optimized working methods and avoid costly and ineffective experiments (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al.,

2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

In the B-Green-ED project, students were trained to recognize and capitalize on the economic benefits of applying standards in various industries. For example, in the quality management and waste management courses, participants learned how to use the standards to optimize production and logistics processes, thereby reducing resource wastage and operational costs. This was particularly relevant for companies aiming to comply with strict environmental regulations and adopt sustainable practices.

Another important aspect of the application of standards is the reduction of redundancies. Standardization avoids the need to develop ad hoc solutions for each project or product, as there are already clear specifications and guidelines that can be followed. This allows companies to save time and resources, especially in international projects, where collaboration between teams from different countries can be simplified thanks to the application of common standards.

3.8. Expanding employment opportunities

In a globalized and dynamic economy, skills related to standardization are becoming increasingly valuable to employers. Education in standardization not only prepares students to comply with regulations and optimize processes, but also provides them with a wide range of skills that broaden their employment opportunities. Understanding and applying international standards is a highly sought-after skill in various industries, from manufacturing and technology to the service sector and public administration (Comité Européen de Normalisation; Leisyte et al., 2015; Mentel et al., 2020; Plakhotnik et al., 2023; Zaporozhchenko et al., 2022).

The micro-credential courses developed under the B-Green-ED project have demonstrated that education in standardization opens doors to a variety of professional opportunities. Students who attended these courses acquired skills that increased their attractiveness on the labor market, as many companies are looking for specialists who understand and can implement the standards needed to access international markets. For example, knowledge of quality management and environmental standards is essential in industries such as the bioeconomy and green energy, where companies must comply with strict regulations.

Moreover, education in standardization provides students with an adaptability that is highly valued by employers. Future professionals become able to quickly integrate into

multidisciplinary and international teams using a common language based on clear standards. This makes students educated in standardization extremely versatile and prepared to take up positions in a variety of fields, from project management to compliance audits and business consulting.

4. Discussions

Although the results of the study indicate numerous benefits of education in standardization, it is important to also consider certain limitations and challenges that have arisen during the implementation of micro-credentialing courses. These shortcomings provide useful insights for further improving educational approaches in this area and extending the positive impact to a wider audience.

One of the limitations of the study is the relatively small sample of students who participated in the pilot courses. Each partner university managed a limited number of trainees, which may influence the ability to generalize the findings to a wider level. Also, the cultural and economic variability between the participating countries (Romania, Bulgaria, Lithuania and Spain) could affect the perception and applicability of standardization education in other national contexts. In addition, micro-credential courses were conducted in a predominantly online or hybrid setting, which may influence the degree of interaction between students and faculty. This teaching method, although flexible, could limit some practical aspects of standardization education, which would require physical interaction or practical exercises to better understand the concrete application of the standards.

In the process of implementing micro-credential courses, one of the major challenges was related to access to adequate educational resources. Since standardization is a technical and specific field, not all teachers had the necessary training to teach this topic effectively, which led to the need for additional training. This aspect can represent a significant obstacle for universities that want to implement similar courses but do not have specific expertise in standardization.

Another challenge was keeping students interested throughout the entire program. Standards, while fundamental to various industries, may seem abstract or complex to students. Finding interactive and dynamic teaching methods was essential to the success of the courses, but it took

extra effort on the part of the teachers to integrate these methods into a basic educational framework.

To overcome these challenges and increase the effectiveness of education in standardization, continuous improvement of teaching methodologies is necessary. One solution would be the integration of more advanced technologies, such as interactive simulations, virtual reality or educational games, which could make standardization more accessible and interesting for students. These technologies would allow students to experience concrete application of the standards in a safe and controlled environment.

At the same time, collaboration with industry could be intensified. Currently, partnerships between academia and the private sector are valuable, but there are unexplored opportunities for industry organizations to be more actively involved in the design and delivery of standardization courses. Thus, the courses would become even more relevant to the current needs of the labor market, and students would benefit from practical experiences in direct collaboration with companies.

Although the results of the study suggest significant benefits of education in standardization, their generalization to a wider context should be done with caution. The piloting of the micro-credential courses was carried out in higher education institutions in Europe, and the applicability of this methodology may vary according to educational and industrial systems in other regions of the world. However, the basic principles of standardiza6on educa6on remain relevant and can be adapted to different national or regional contexts.

Although standardization education demonstrates undeniable value in training the next generation of experts, it is important that institutions consider these limitations and challenges in order to maximize its impact and relevance. Proposed improvements and closer collaboration between academia and industry could turn this initiative into an internationally replicable model.

5. Conclusions

Education in standardization is emerging as a fundamental approach for the training of future experts who will have to face the complex challenges of a globalized, digitized and sustainability-oriented economy. Our study, conducted as part of the B-Green-ED project,

demonstrated the significant benefits of integrating standardization-focused micro credentials into higher education. Through these courses, students had the opportunity to acquire essential skills not only for regulatory compliance and quality improvement, but also for promoting innovation and collaboration in interdisciplinary and international environments.

The results of this study clearly indicate that education in standardization should not be seen only as an educational option, but as a necessity for future professionals who will work in key sectors of the economy, such as bioeconomy, engineering, information technology and waste management. The eight reasons identified in our research highlight the diversity of advantages that this form of education can offer: from improving global skills and stimulating innovation within safe limits, to reducing costs and expanding employment opportunities.

However, in addition to these benefits, our study also revealed a number of limitations and challenges that require further attention. First, the limited sample of students and the specific context in which the micro-credential courses were conducted require caution in generalizing our findings internationally. Also, the challenges related to the training of teachersn to teach such a technical and specific field, as well as the difficulties in maintaining students' interest in a subject perceived as abstract, require innovative solutions and more advanced pedagogical methodologies.

Active involvement of industry in the design and delivery of standardization courses is essential to increase their relevance. Partnerships between academia and the private sector must be strengthened to ensure that education in standardization reflects the realities and needs of the labor market. Companies in industry sectors that depend heavily on standards compliance – such as manufacturing, technology and energy – can directly contribute to the development of relevant educational programs and provide students with access to internships and real-world applications of the standards in the business environment.

Another practical direction is the use of advanced technologies to make standardization education more attractive and interactive. Simulations based on virtual or augmented reality, as well as interactive educational platforms, could facilitate applied learning of the standards and increase student interest in this field. These technologies could simulate complex industrial processes where standards are applied in real time, providing students with a safe environment

for experimentation and learning.

Based on the results obtained and the limitations identified, there are several future research directions that can deepen the understanding of the impact of education in standardization on professional and economic development.

- **Extending studies to a larger international sample**. To obtain a more comprehensive picture of the effects of education in standardization, it is necessary to expand the research internationally, involving universities and institutions in other geographical regions. Comparative studies between different educational systems and industries can reveal new insights into the applicability of standardization and the cultural and economic variables that influence the success of this form of education.

- **Long-term evaluation of the impact of micro-credentials**. An important aspect worth researching is the long term evaluation of the impact of standardization education on students' careers. To what extent have the skills acquired through these courses influenced their professional path? What positions do these students occupy within companies and how often do they apply knowledge of standards in their work? Longitudinal studies could provide valuable answers to these questions.

- **Exploring new technologies in teaching standardization**. Another interesting area of research is evaluating the effectiveness of new technologies in teaching standardization. How can teaching methods based on simulations, virtual reality or artificial intelligence be used to improve learning? Future research can investigate how these technologies can be integrated into educational programs to increase student engagement and retention.

- **The impact of university-industry collaboration on the quality of education.** Future research could look in depth at the impact of university-industry collaborations on the quality of education in standardization. To what extent does the involvement of companies in the design of educational programs contribute to their relevance and timeliness? This line of research could highlight good practices and develop new models of collaboration between academia and the private sector.

- **Standardization for new emerging industries**. In the context of rapid changes in the technological and economic landscape, future research could explore the role of education in

standardization in emerging industries such as artificial intelligence, blockchain or the circular economy. To what extent are current standards applicable to these new fields, and how can standards education prepare experts for the unique challenges of these industries?

Education in standardization is an essential element in building a workforce capable of managing the complexities of the global market and meeting the challenges of sustainability, innovation and compliance. Although there are limitations and challenges associated with its implementation, its benefits are undeniable. The future research directions proposed in this paper offer opportunities to deepen and expand our understanding of this vital field, thus contributing to the development of a more efficient, sustainable and compliant economy with international regulations.

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