IT STANDARDIZATION IN EDUCATION: A COMPARISON OF ISO/IEC AND IEEE STANDARDS PRICE

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Original scientific paper
https://doi.org/10.7251/JIT2501038K UDC: 006.3/.8:[007:004.056.5

Abstract: Standardization exists in all areas of human activity and is an essential factor in contemporary manufacturing, banking, healthcare, education, and other organizations. Its key role in education is seen in promoting system interoperability through the application of learning technologies, which enables continued development in the field. This paper discusses the standardization regarding the application of information technologies in education, including e-learning. This paper aims to examine, through statistical analysis, specifically by using an appropriate T-test, whether the prices between the two groups of standards, ISO/IEC and IEEE, differ significantly from a statistical perspective.

Keywords: analysis, education, information technology, standardization

INTRODUCTION

We live in an era of change, which makes it challenging to harmonize standardization with the development of a specific field [1]. Standardization can be described as activities that identify and align common elements from various inputs to support interoperability and create a level playing field for further innovation and technology adoption [2].

After reviewing the literature and related research, the concept of standardization and standards was presented. Then, attention was paid to the study of standardization in the application of information technologies in education, including e-learning, and a selection of standards published by international organizations for standardization was made. The work includes a statistical analysis of standards related to the research field published by selected international organizations for standardization.

Literature Review

Interest in applying information technologies in education has become particularly relevant in recent years. However, few analyses and works have been published regarding standardization in this area. Based on a review and detailed analysis of the available literature, several recent pertinent works in this field have been identified.

Hoel and Mason [1] discuss using digital technologies in smart learning environments, presenting two models of smart learning. These models are analyzed in the context of current advances in the standardization of learning, education, and training. The goal is to establish a basis for the development of a platform that supports new standards in this area.

Recent research has increasingly focused on standardization in digital education technologies. One study [1] examines smart learning environments through two conceptual models, analyzing them within current standardization frameworks for education and training to establish foundations for future standard development platforms.

A comparative analysis [3] evaluates e-learning standards from ISO alongside regional standards organizations, identifying significant similarities and differences in both publication patterns and pricing structures across jurisdictions.

Further research [4] investigates knowledge innovation patterns across standardized IT application domains through comparative analysis. Building on this work, a subsequent study [5] provides a systematic review of international e-learning standardization efforts, particularly examining ISO/IEC JTC 1 SC 36's work on education technologies and standards development for MOOCs.

Additional analysis [6] systematically examines both international and national standardization efforts in distance learning, with particular attention to development trends and organizational frameworks in the Serbian context, comparing local and global standardization practices.

A comprehensive regional study [7] analyzes e-learning standards published between 2004 and 2017, comparing international standards with national standards from Serbia and neighboring countries (Bosnia and Herzegovina, Croatia, North Macedonia, Montenegro, Albania, Hungary, Romania, and Slovenia). The research employs statistical methods to examine development trends, publication volumes, and pricing structures, revealing correlations between national and international standardization efforts.

Standardization and Standards

Standardization is the process of determining and applying specific rules to organize and regulate activities in a particular area, benefiting all interested parties and particularly aiming for overall optimal savings. This process takes into account functional purposes and technical security requirements [8]. The significance of standardization is evident in its role in stabilizing and establishing a foundation for improvements, based on the following principles [9]:

- voluntary participation of all interested parties in the process of adoption of standards;
- voluntary implementation of standards;
- harmonizing the views of interested parties regarding the technical content of the standard is achieved by consensus;
- publicity and transparency of the standard adoption procedure;
- mutual conformity of standards;
- achieving optimal benefits for society as a whole.

A standard is a document that provides conditions, specifications, guidelines, or characteristics that can be used to ensure that materials, products, processes, and services are fit for purpose. Standards are established by consensus and approved by recognized bodies [9].

International Standards

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) establish a specialized global standardization system. ISO has developed over 24438 international standards, all of which are included in the ISO standards catalog. The IEC prepares and publishes international standards for electrical, electronic, and related technologies, while the ISO also develops standards for other fields [10].

The Institute of Electrical and Electronics Engineers (IEEE) is a professional association for electronic and electrical engineering. IEEE is the leading standards development organization, developing and maintaining standards through the IEEE Standards Association (IEEE-SA). The IEEE-SA standards development process is open to both members and non-members. However, IEEE-SA membership allows participants to engage more deeply in the standards development process, providing additional opportunities for voting and participation. IEEE-SA also collaborates with global, regional, and national organizations to ensure the effectiveness and visibility of IEEE standards within the IEEE and the global community.

European standard

A European standard is a standard adopted by the European Organization for Standardization (CEN/CENELEC/ETSI). It is implemented as an identical national standard, requiring the withdrawal of all national standards that conflict with it. If the European standard was adopted at the request of the European Commission for use in the harmonized legislation of the European Union, it is referred to as a harmonized standard [9].

There are three regional organizations for standardization in the European Union [10]:

- European Committee for Standardization - CEN,
- European Committee for Electrotechnical Standardization - CENELEC
- European Telecommunications Standards Institute - ETSI.

Each body develops standards for different areas. CENELEC specializes in electrical engineering, ETSI in information and communication technologies, while CEN covers all other areas.

Serbian standard

The Serbian standard is a standard adopted by the Institute for Standardization of Serbia (ISS) as a national standards body and is available to the public. It is marked with a symbol that begins with the abbreviation SRPS. The application of Serbian standards is voluntary, which means that there is no automatic legal obligation to apply them. However, laws and technical regulations may refer to standards, making compliance with them mandatory.

Serbian standards can be original or can be created based on international, European, and other regional standards and related documents, as well as national standards and related documents of other countries, following the agreements signed with the national standardization bodies of those countries. Standards are developed and defined through the process of knowledge sharing and good practice and are built based on a consensus reached between experts who represent stakeholders in standards commissions [9].

Standardization in the field of application of information technologies in education

There are various possibilities for applying information technologies in education. According to the international classification for standards, the application of information technologies in education is ranked within the 35.240.90 subgroup (ISO 35.240.90 group of standards) [11].

IEEE is a leader in engineering and technology education that provides resources for pre-university, university, and continuing professional education [12]. IEEE Learning Technology Standards Committee - IEEE LTSC follows an open and transparent formal standards development process and fully supports IEEE's sponsorship of the OpenStand initiative [13].

For research purposes, the IEEE 1484 series of standards was selected. These standards cover a wide range of systems known as learning technology, education and training technology, computer-based training, computer-assisted instruction, and intelligent tutoring [14], [15]. The IEEE 1484 series of standards for eLearning Technologies specifies a high-level architecture for information technology-supported learning, education, and training systems that describes high-level system design and system components for the eLearning Technologies family of standards [16].

METHODS AND MATERIALS

Data Description

The goal of this research is to provide a snapshot of the state of standardization at the international level in the application of information technologies in education, including e-learning. To determine the actual state of standardization, two international organizations that extensively cover this research area were selected. Specifically, an analysis was conducted on the standards published by the International Organization for Standardization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE).

Data on these published standards were gathered from the internet by searching the available catalogs on the official websites of ISO and IEEE. After identifying the appropriate group of standards, they were reviewed along with their current status, and standards that are not active were excluded from further analysis.

Data pre-processing

In the pre-processing stage, the data is prepared for analysis using one of the most popular software applications for statistical processing and data analysis, SPSS. This program was developed by the American company IBM in 2009 and now represents only a part of the suite of software products offered by this company for collecting, storing, and processing data. Standards differ from one another based on certain characteristics (label, price, date, status, etc.), which allows for comparison and analysis. Table 1 provides an overview of ISO/IEC and IEEE standards related to the research area, and information about them is entered into the software and prepared for further analysis. To ensure the comparability of the selected groups of standards and facilitate their processing, the t-test for independent samples was used for further analysis. This test compares the mean value of a continuous variable between two different groups of subjects. The analysis was preceded by an examination of the assumptions underlying the t-test.

Table 1. *Standards in the field of information technologies for learning, education, and training (extract from the table)*

Standard	Price (CHF)
ISO/IEC TR 4339:2022	65.00
ISO/IEC 12785-1:2009	.00
ISO/IEC 12785-1:2009/Cor 1:2013	.00
ISO/IEC 12785-2:2011	.00
ISO/IEC TR 127853:2012	.00
ISO/IEC TR 18120:2016	199.00
ISO/IEC TR 18121:2015	98.00
ISO/IEC 19479:2019	155.00
ISO/IEC 19778-1:2015	155.00
ISO/IEC 19778-2:2015	132.00
ISO/IEC 19778-3:2015	98.00
ISO/IEC 19780-1:2015	98.00
ISO/IEC 19788-1:2024	.00
ISO/IEC 19788-2:2011	132.00
ISO/IEC 19788-2:2011/Amd 1:2016	18.00
ISO/IEC 19788-3:2011	155.00
ISO/IEC 19788-3:2011/Amd 1:2016	155.00
ISO/IEC 19788-4:2014	98.00
ISO/IEC 19788-5:2012	155.00
ISO/IEC 19788-7:2019	221.00
ISO/IEC 19788-8:2015	155.00
ISO/IEC 19788-9:2015	132.00
IEEE 1484.11.1-2022	72
IEEE 1484.11.2-2020	60
IEEE 1484.12.1-2020	70
IEEE 1484.12.3-2020	80
IEEE 1484.13.1-2012	173
IEEE 1484.13.2-2013	131
IEEE 1484.13.3-2014	77
IEEE 1484.13.4-2016	62
IEEE 1484.13.5-2013	77
...	...

Selection of dependent and independent variables

After the pre-processing phase in which the data were prepared for processing, the next step involved the selection of dependent and independent variables (Table 2). The price of the standard was chosen as the dependent variable, while the other variables are independent. The data is grouped into one of two ISO/IEC or IEEE categories, and all prices are expressed in the same currency (Swiss Franc - CHF) for easy comparison.

Table 2. *Review of variables*

Name	Type	Values	Measure
Group	String	1-ISO/IEC 2-IEEE	Nominal
Label	String	/	Nominal
Name	String	/	Nominal
Price	Numeric	/	Scale

Results and Discussion

Statistical analysis using the t-test method of independent samples in this paper was conducted in order to determine the price differences in the selected groups of standards. Namely, the research question was asked: Is there a statistically significant difference between the mean values of the prices of standards group 1 (ISO/IEC) and standards group 2 (IEEE)?

The results of price tests of ISO/IEC and IEEE standards were compared. In addition to the continuous dependent variable that indicates the price of the standard, a categorical variable that indicates the group of standards was determined (1 - group of ISO/IEC standards, 2 - group of IEEE standards).

The assumptions and hypotheses set during the analysis are as follows:

- H0: The price difference between ISO/IEC and IEEE standards is not statistically significant.
- H1: The price difference between ISO/IEC and IEEE standards is statistically significant.

After checking the fulfillment of the corresponding assumptions required by the t-test of independent samples, it was applied, and the results of the application of this statistical method are presented in Tables 3 and 4.

Table 3. *Group Statistics*

	Group	N	Mean	Std. Deviation	Std. Error Mean
Price	ISO/IEC	54	123.8333	56.19768	7.64754
	IEEE	12	91.9667	34.77777	10.03948

The Group Statistics table shows the number of samples (N) for both groups of standards, the mean value of the standard price, the standard deviation from that value for each group, and the standard error of the mean. The first part of Table 4 presents the results of Levene's test for equality of variances. As the value of Sig. is greater than 0.05 and is 0.054, it is

Table 4. *Independent Samples Test*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Price	Equal variances assumed	3.852	.054	1.879	64	.065	31.86667	16.95739	-2.00962	65.74295
	Equal variances not assumed.			2.525	25.675	.018	31.86667	12.62046	5.90896	57.82437

concluded that the assumption of equality of variance is not violated.

To assess the significance of the difference between the mean values of the dependent variable (price) in each of the groups of standards, it is necessary to analyze the value of Sig. (2-tailed) In the t-test for the Equality of Means section. As it was established in the previous interpretation of the results that the assumption of equality of variance was not violated, it is necessary to look at the value of Sig. (2-tailed) listed in the first row of the table, which refers to the assumption of equality of variance. This value is 0.065, and since it is higher than the threshold value of 0.05 it should be concluded that there is no statistically significant difference between the average prices of the ISO/IEC and IEEE standards groups, i.e. the price difference between the two standards groups is not significant but random, which confirms the null hypothesis - H0.

In addition to the analyzed data, the Independent Samples Test table also contains data on the mean value of the difference between the two groups of Mean Difference standards, which is 31.86667, as well as the upper (65.74295) and lower (-2.00962) limits of the interval, which with a probability of 95% contain the real size of that difference.

When it comes to the results of related research, the conclusion is reached that there are more papers available that talk about standardization in the field of e-learning. The papers mainly talk about the development trends of standardization in the field of e-learning or deal with the analysis and comparison of standardization in the mentioned field at the national and international levels. However, no work was found that deals with the analysis and comparison of selected groups of international standards, so it is not possible to perform an adequate comparison of the obtained results.

CONCLUSION

Modern organizations rely heavily on IT standards to reduce costs, ensure flexibility, and facilitate the planning, implementation, and operation of information systems. In addition to great advances in the economy, the application of technology has contributed to the development of education in many ways. In fact, its role has proven to be the expansion of access to education. Standardization, as an important component of the quality management process, requires its presence in almost all areas of human activity, especially in the area of education, since quality education is the foundation of the progress of modern society. The application of information technology in education was of great importance when the world faced the coronavirus epidemic. These extraordinary circumstances brought significant challenges in the field of education.

Acceptance of innovations and significant progress in the adoption of information technologies in the field of education leads to the need for standardized sources of knowledge. To analyze the state of standardization in the field of application of information technologies in education at the international level, the data set used for analysis in this paper includes the world's standardized sources of knowledge, ISO/IEC and IEEE, in the previously mentioned field of research. Namely, after the research and analysis of collected data sources were conducted, a t-test of independent samples was conducted on the selected data set, and it was determined whether the price difference between ISO/IEC and IEEE standards was statistically significant. The results showed that the differences in the price of standards created by ISO/IEC and IEEE organizations are not statistically significant.

The statistical analysis includes all ISO/IEC standards within the 35.240.90 subgroup and all stan-

dards from the IEEE 1484 series of standards. Future research may be based on the inclusion of additional subgroups of standards or the expansion of data categories for analysis.

Based on the analysis of the state of standardization in the field of application of information technologies in education and the conducted research, it was observed that in this field of research, it is necessary to work on improving standardization. The need for cooperation in the field should be emphasized, both at the national and at the European and international levels.

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Received: March 7, 2025
Accepted: April 20, 2025

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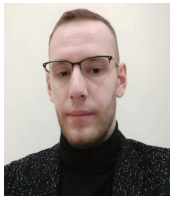

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FOR CITATION

Marija Krstić, Lazar Krstić, Valentina Stanković, IT Standardization in Education: A Comparison of ISO/IEC and IEEE Standards Price, *JITA – Journal of Information Technology and Applications, Banja Luka*, Pan-Europien University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 15(2025)1:38-44, (UDC: 006.3/.8:[007:004.056.5), (DOI: 10.7251/JIT2501038K), Volume 15, Number 1, Banja Luka, June (1-80), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004