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Design of Methodological Platform to Support the Integration of Standardized Quality Management Systems Applicable in the Mining Industry

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Abstract
Although quality management systems are discussed in the professional field, methodological recommendations guiding modification processes related to the integration or conversion of standardized quality management systems are absent in both scientific and professional circles. The presented paper reflects on these facts and offers an instance of the development and application of a new methodology that would help in decision-making processes in companies. Although the authors' methodology is presented in the context of educational institutions, given the aim of ISO 9001 and the need for changes in the sectors related to ensuring increasingly high-quality processes in companies, this methodology can also be applied in the mining industry, the manufacturing sector and service sector. The Slovak Accreditation Agency for Higher Education (SAAHE) issued new quality standards for Slovak universities in 2020 (SAAS 2020). The previous accreditation rules determined requirements and criteria for quality management system (QMS) implementation, maintenance and improvement. Therefore, some Slovak universities implemented ISO 9001 in the past. It is necessary to convert their QMS from ISO 9001 to SAAS 2020. The main objectives of this paper are: to identify selected common requirements of both standards, to define three basic dimensions of QMS conversion, to use vector analysis for quantifying conversion relevance (CR) and conversion strength (CS) and to recommend which requirement should be preserved or converted. Conversion is vector **AB**, where initial position **A** = (A_x, A_y, A_z) represents ISO 9001 and the new position **B** = (B_x, B_y, B_z) represents SAAS 2020.

Keywords
quality management system, conversion, vector analysis, ISO 9001, mining industry

Introduction

Higher education in the Slovak Republic is undergoing a paradigmatic change. The Slovak Accreditation Agency for Higher Education (SAAHE), established in 2019 as a new independent organization, issued new standards and criteria for quality assurance in higher education institutions in 2020 (SAAS 2020). Requirements and criteria determined in the SAAS 2020 are based on the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG 2015). However, some Slovak universities implemented and maintained their quality management system according to ISO 9001 in the past.

Can the current quality management system, in accordance with ISO 9001, cover new quality requirements defined in the SAAS 2020? Can two parallel quality management systems exist, or should they be integrated? Is it better to convert one QMS to the other one? And are all requirements worthy of conversion? Those research questions were verified at Matej Bel University in Slovakia, which has 6 faculties and approximately 500 employees. This university had certified QMS according to ISO 9001 until a new quality standard was issued in 2020. University top management hesitated about how large should be the maintenance of the previous QMS. The answer was very simple. Some ISO 9001 requirements can be preserved, and some requirements can be converted to the SAAS 2020. However, the simple answer had to be built on a real and strong baseline. How significant is the selected quality requirement according to ISO 9001 or the SAAS 2020? How effective is applying the selected quality requirement, and is there sufficient employee awareness? These three areas (significance, effectiveness and employee awareness of the selected quality requirement) led us to a vector analysis as a three-dimensional method for evaluating quality management system conversion possibilities. Utilization of the vector analysis is general, and it does not depend on concrete quality management systems issued as a standard. The most important is to define three space dimensions. The vector analysis results show conversion relevance (CR) and conversion strength (CS) for recommending which requirement should be preserved or converted.

The main objectives of this paper are:

(1) to identify selected common requirements of the ISO 9001 and SAAS 2020;
(2) to define three basic dimensions of QMS conversion (axis x = Significance, axis y = Effectiveness and axis z = Employees` awareness of the selected quality requirement);
(3) to use vector analysis for quantifying conversion relevance (CR) and conversion strength (CS);
(4) and to recommend which requirement should be preserved or converted.

This paper also has a methodological benefit for researchers and practitioners as well. It shows how to compare two quality management systems issued as standards (standardized QMS), with both having at least one common requirement.

Literature review

We focused on areas that were necessary and related to quality management system conversion covering our research in the literature review. Even if we compare two quality management systems, ISO 9001 and SAAS 2020, the results presented in the paper are applicable to any other standardized QMS in the case where there are at least two, and they have at least one common requirement.

In theory, we can implement, integrate or convert standardized QMS. Integration usually means combining a new standardized QMS with the existing standardized QMS and then implementing, yet for the organization, this means at least two new quality management systems and their subsequent implementation. QMS conversion is a different process from integration. Conversion causes the demise of one system and the existence of a new system. During QMS conversion, and if it is applicable, some common requirements of both quality management systems can be applied in the same way. Conversion relevance (CR) determines the preservation or conversion of the selected quality requirements. Conversion strength (CS) shows how strong is the necessity of conversion. CR and CS result from the vector analysis proposed in this paper.

Integration of standardized management systems usually involves the integration of ISO 9001, ISO 14001 and ISO 45001 in practice. Some authors also offer integration of non-standardized systems; for example, Nurcahyo, Apriliani, Muslim & Wibowo present an analysis of the implementation of 5-S principles integrated with ISO 9001 requirements at the higher education level. Luczak & Wolniak (2016) present an almost traditional integration of quality, environment and safety management systems. They defined a quality management system as a basic management structure in the enterprise into which elements of environmental management and work safety management are incorporated. They described some problems of management system integration in detail. Also, Jagannathan (2008) presents the integration of QMS and environmental management system (EMS). Ali (2014) compares the requirements of two standardized QMS. He compared two QMS, namely ISO 9001 and QLASSIC. Comparison of both QMS did not use a vector analysis, but some comparison principles we adapted in our research process of finding common requirements. Chen & Chen (2012) show the integration of Total Quality Management (TQM). They proposed the NHFS model based on the integration of TQM in Taiwanese universities.

As we stated, integration can be one standardized management system, and its requirements to the other or one standardized management system can be implemented isolated, as is presented by Kras, Svilicic & Covo (2007). The use of information technologies for the integration of an enterprise QMS with the requirements of the related standards is described by Vasiliev, Velmakina, Mayborodin & Aleksandrova (2020). We will not deal with information technology in our research. These technologies greatly simplify requirements application, but we looked for the prerequisites of QMS conversion decisions.

We compare ISO 9001 and the new SAAS 2020 standard issued by SAAHE. We looked for the same requirements, even if they are defined differently. However, their application in university practice is the same. Therefore, it is necessary to analyze studies of ISO 9001 and ESG 2015 because SAAS 2020 is based on ESG 2015. We abstract from any specifics and requirements for teachers' work as described by Osvaldova & Vrabcova (2020), Osvaldova & Vrabcova (2021) and Osvaldova (2016). Schmuck (2021) compared ESG 2015 and ISO 9001, and his paper motivated us to compare these standards in detail. He stated that ESG 2015 is replacing ISO 9001 in the European higher education sector, and there are numerous challenges in implementing ESG 2015 at higher education institutions. Please note that not all universities have implemented ISO 9001. His study reveals the similarities and differences between ESG 2015 and the ISO 9001 principles. With methodology, he used a pairing of ESG 2015 with ISO 9001. The outcome of Schmuck's study shows that all of the ISO 9001 principles are included in the ESG, but only seven out of ten ESG guidelines are included in the ISO 9001 principles. However, we are interested in selected identical requirements, which are precisely defined in ISO 9001 and SAAS 2020 as they are numbered. Jambor, Dzubakova & Habanik (2017) made a similar attempt to compare ESG 2015 and ISO 9001. They analyzed specific requirements applicable to higher education, but the conversion was not the goal. Their paper describes an approach to creating a quality management system in higher education based on the integration of ESG 2015 and ISO 9001:2015 requirements and shows experience with positive synergies of both standards. Also, Kasperaviciute-Cerniauskiene & Serafinas (2018) describe the adoption of ISO 9001 standards within higher education institutions in Lithuania. However, they focus only on ISO 9001. Morales, Castro & Medina (2017) made a comparative study of conformity analysis procedures in institutions of higher education in the Republic of Ecuador in terms of the regulation of quality accreditation and ISO 9001. Their approach is based on a comparison of accreditation criteria and the ISO 9001 requirement.

Our methodology and approach allow different organizations to decide whether to preserve or convert a clear but differently defined requirement of one and the other QMS, which is equally applicable in practice. This methodology is also applicable in another sector, not only in higher education. However, we chose Matej Bel University as an example. Therefore, we also researched papers dealing with higher education quality. SAAS 2020 was issued by SAAHE. This Slovak accreditation agency was established in 2019. Higher education quality assurance and accreditation is described by Rivero & Lopez (2021); Dayananda, Latte, Raisinghani & Sowmyarani (2021); Hanh (2020); Andreani, Russo, Salini & Turri (2020); Bendixen & Jacobsen (2020); Iniguez & Tobon (2019); Watstein & Ivins (2019), Hall (2012); Ramirez (2015 and Sarakinioti & Philippou (2020). Stura, Gentile, Migliaretti & Vesce (2019) state that quality assurance in higher education was totally reformed in the last decades. Makhoul (2019) investigated whether outside quality confirmation can truly influence the inward life of higher education institutions. About the German higher education accreditation regime, say Schneijderberg & Steinhardt (2019). Auz, Rivero & Lopez (2018) fostered some reflections on the improvement plan within the framework of the accreditation of quality in higher education institutions. Murmura, Casolani & Bravi (2016) proposed seven keys for implementing the self-evaluation, periodic evaluation and accreditation (AVA) method to improve quality and student satisfaction in the Italian higher education system. Delgado, Reyes & Munoz (2014) present the results of analysis on the emerging issue of evaluation and accreditation of education, and they discuss concepts of quality assessment-improvement. Linking ISO 9001 and ISO 26000 with accreditation requirements for quality indicators in higher education was made by Yeung (2018). His results are based on ISO 9001 clauses and the seven dimensions of ISO 26000 CSR guidelines and programme accreditation requirements. These three levels he converted into quality indicators for assessing the quality performance of higher education institutions in terms of their sustainability.

Vector analysis of QMS conversion: a theoretical model for comparing two standardized quality management systems

The literature review confirmed that the integration of different quality management systems could enhance quality assurance in the organization. However, if an organization decides to convert its quality management system, it must decide which post-conversion requirements will apply to the new and which to the old ways. These decisions relate to requirements that are identical for both the previous (ISO 9001) and the new (SAAS 2020) QMS.

The method we used to solve this problem is vector analysis. The organization's decision is thus supported by quantitative analysis. Vector analysis is usually used in natural sciences; for example, De Bernardo, Vitiello, Abbinante & Rosa (2019) used vector analysis for the comparison of standard cross-linking and photorefractive

keratectomy combined with accelerated cross-linking in keratoconus management or Di Somma, Vetrone & Maisel (2014) described bioimpedance vector analysis for diagnosis and management of acute heart failure. Duran, Gutierrez, Atienza & Pinero (2017) did vector analysis of astigmatic changes and optical quality outcomes and He, Zhao, Tian, Shi & Huang (2013) used vector analysis for land-cover change detection.

We also use vector analysis in an analogical way. Our three dimensions help us determine the vector length and its direction, which represents conversion strength from one QMS to another expressed as a multiple of the vector length and the weight (relevance) of the individual dimensions. Dimensions of any QMS conversion, conversion relevance and conversion strength are described below.

Dimensions of QMS conversion

The prerequisites for vector analysis of the quality management system conversion contain the following:

(5) The existence of at least two standardized quality management systems or comparable standardized management systems in general;
(6) At least one common requirement for both standardized quality management systems;
(7) Although the common requirement is defined in different ways, it must be applied in the same way in practice;
(8) There must be three parameters (dimensions) by which the two standardized quality management systems can be compared, and the parameters must be quantifiable.

Following the above conditions, we determined these three dimensions for quantifying the decision to convert selected quality requirements:

- Significance of the selected quality requirement;
- Effectiveness of the selected quality requirement;
- Employees' awareness of the selected quality requirement.

If we denote the original standardized QMS (ISO 9001) as vector **A** and the new standardized QMS (SAAS 2020) as vector **B**, then:

$$\mathbf{A} = (A_x, A_y, A_z) \tag{1}$$

$$\mathbf{B} = (B_x, B_y, B_z) \tag{2}$$

where *x* represents the significance of the selected quality requirement, *y* represents the effectiveness of the selected quality requirement, and *z* represents employees' awareness of the selected quality requirement, and for the vector, the direction is defined in vector coordinates as follows:

$$\mathbf{BA} = (B_x - A_x, B_y - A_y, B_z - A_z) \tag{3}$$

a) Axis x: Significance

The first dimension of the vector is the significance of the selected quality requirement. It represents the value of how real is the impact of the selected requirement on higher education quality. A common requirement of both standards has to be equally applicable in management practice.

The significance values are recorded on the x-axis, where $x \in [1, 5]$ and $x \in Z^+$, where Z^+ is the set of all positive integers. In our research, significance of the quality requirement defined in the standards can take on the following values: 1 = very low; 2 = low; 3 = medium; 4 = high or 5 = very high. If we denote the same common requirement for both compared standardized management systems as R_i, where $i = (1, 2, \ldots, m)$ and m is the finite number of common requirements, then we must determine the significance value A_x for one and B_x for the other standard being compared.

In case of a very high impact on the quality of higher education, the application of the requirement will really improve the quality and create the preconditions for its maintenance and continuous improvement. In case of very low impact, the application of the requirement has no significant impact on quality and its improvement. The significance value must be determined by the person responsible for quality. Thus, two values are always determined for the new and for the old QMS.

b) Axis y: Effectiveness

The second dimension of the vector **BA** is the effectiveness of the selected quality requirement. It represents the ratio between outputs related to the selected quality requirement to inputs that are necessary for its achievements. If the outputs are measurable, then the inputs must also be measurable in the same units. If the output can only be evaluated subjectively, the inputs to achieve it must also be evaluated subjectively. This dimension is expressed as the previous one; values are recorded on the y-axis, where $y \in [1, 5]$ and $y \in Z^+$, where Z^+ is the set of all positive integers. Effectiveness of the quality requirement defined in the standards can take on the following values: 1 = very low; 2 = low; 3 = medium; 4 = high or 5 = very high. If we denote the same common

requirement for both compared standardized management systems as R_i, where $i = (1, 2, \ldots, m)$ and m is the finite number of common requirements, then we must determine the effectiveness value A_y for one and B_y for the other standard being compared.

The efficiency of the selected quality requirement is best expressed in terms of cost. Then we can determine the cost-benefit ratio. In the case of intangible outputs or outputs that cannot be directly valued, we must determine the value of efficiency subjectively. Thus, two values are always determined for the new and for the old QMS.

*c) **Axis z: Employees awareness***

The third dimension of vector **BA** is the employee's awareness of the selected quality requirement. It represents how well employees know the requirement's theoretical definition and practical application. This dimension is recorded on the z-axis, where $z \in [1, 5]$ and $z \in Z^+$, where Z^+ is the set of all positive integers. Employees awareness of the quality requirement defined in the standards can also take on the following values: 1 = very low; 2 = low; 3 = medium; 4 = high or 5 = very high. If we denote the same common requirement for both compared standardized management systems as R_i, where $i = (1, 2, \ldots, m)$ and m is the finite number of common requirements, then we must determine the employee's awareness value A_z for one and B_z for the other standard being compared. Unlike the previous dimensions, there is a need to define options more clearly for employees. The R_i values for both compared standards are not determined by quality managers or top management but by employees. It is recommended that values should be determined by employees who have experience with a standardized QMS. Therefore, we can determine this scale from 1 to 5:

- 5 (very high): I know the definition of the requirement; I know how it is applied in practice, and I know my contribution to its assurance;
- 4 (high): I do not know the definition of the requirement; I know how it is applied in practice, and I know my contribution to its assurance;
- 3 (middle): I do not know the definition of the requirement, I do not know how it is applied in practice, but I know what is my contribution to its assurance;
- 2 (low): I do not know the definition of the requirement, I know how it is applied in practice, but I do not know my contribution to its assurance;
- 1 (very low): I do not know the definition of the requirement; I do not know how it is applied in practice, and I do not know my contribution to its assurance.

Again, two values must be determined by each employee for one common requirement (old and new standardized QMS) due to vector calculating.

Conversion relevance and conversion strength

If we know the three dimensions of the vector and have the coordinates of the vector, we can quantify Conversion Relevance (CR) and Conversion Strength (CS) to recommend which requirement should be preserved or converted. CR is a number that takes on values from -4 to +4. These two extremes indicate whether it is appropriate to apply the common requirement of the new standardized QMS in an original way in accordance with the old standardized QMS (preservation; min. value -4) or in the new way (conversion; max. value +4). The following relation applies to determine the CR value:

$$CR = 0{,}6\ (B_x - A_x) + 0{,}3\ (B_y - A_y) + 0{,}1\ (B_z - A_z) \tag{4}$$

Relevance means that we can assign weights to dimensions. For the first dimension (significance), the weight is at level 0.6; for the second dimension (effectiveness), the weight is at level 0.3; and for the third dimension (employees' awareness), the weight is 0.1. We determined these values on the basis of interviews with 10 quality managers of Slovak universities.

We also need to know the Conversion Strength (CS) for the final quantification of requirement preservation or conversion decision. CS is calculated as a multiple of the Vector Length (VL) and Conversion Relevance (CR). The length of the vector represents the force of need and, based on the principles of vector analysis, is calculated as follows:

$$VL = 1(A, B)\sqrt{(A_x - B_x)^2 + (A_y - B_y)^2 + (A_z - B_z)^2}; \text{ and then} \tag{5}$$

$$\mathbf{CS} = \mathbf{VL} \times \mathbf{CR} \tag{6}$$

We determined three dimensions of QMS conversion, and then we can apply vector analysis. We proposed the supporting mathematical model, which allows for the quantified conversion strength of selected requirements of two comparable standardized quality management systems. In the following text, we show a real example of

the conversion from ISO 9001 to SAAS 2020 (based on ESG 2015) and the example of Matej Bel University in Slovakia.

Vector analysis of QMS conversion: form ISO 9001 to SAAS 2020 in Slovak higher education

The mathematical model to support the decision-making of the preservation or conversion of the selected quality requirements was applied to the example of two QMS, ISO 9001 and SAAS 2020.

The application of vector analysis was carried out in several steps in accordance with the objectives of this scientific article:

(9) Analysis of ISO 9001 and SAAS 2020 requirements;
(10) Comparison of standards and identification of common requirements that can be applied in the same way;
(11) Determination of significance of the same requirements by an expert evaluation (persons responsible for quality);
(12) Determination of requirements application effectiveness by an expert evaluation (persons responsible for quality);
(13) Analysis of employees' awareness of the selected requirements through a questionnaire;
(14) Calculation of vector coordinates as the difference of values between the common requirements of ISO 9001 and SAAS 2020 and determination of vector length;
(15) Calculation of the Conversion Strength that indicates the need to convert or preserve a given quality requirement application.

a) Common requirements of ISO 9001 and SAAS 2020

Analysis of both standards was carried out in three phases. The first phase was the analysis of ISO 9001 and SAAS 2020, the second phase was the assignment of the same requirement defined in ISO 9001 to the requirement in SAAS 2020, and the last phase was elaborating a list of requirement numbers that are equal. Equality does not mean the same text but rather the same application method in practice.

In the analysis, we focused on each sentence in both standards in order to determine as much compliance between ISO 9001 and SAAS 2020 as possible. The SAAS 2020 standard is available on the website of the Slovak Accreditation Agency for Higher Education. Its original title is Standards for the Higher Education Internal Quality Assurance System; we refer to it as SAAS 2020. This standard has an assessment methodology with criteria and it is named "Methodology for the Evaluation of Standards". This methodology contains 104 criteria, which we compared with ISO 9001. Table 1 shows 20 identified common requirements, where R_i represents the same common requirement for both compared standardized management systems. The set of common requirements $R = (R_1, ..., R_i, ... R_m)$, where $m = 20$.

Tab. 1. Common requirements of ISO 9001 and SAAS 2020

R_i	R_i^{SAAS}		R_i^{ISO}
R_1 =	*IS 2.1.1*	≈	*5.2.1 a)*
R_2 =	*IS 2.3.1*	≈	*6.2.1*
R_3 =	*IS 2.3.2*	≈	*6.2.1 a)*
R_4 =	*IS 2.4.3*	≈	*4.4.1*
R_5 =	*IS 2.4.4*	≈	*5.3 b)*
R_6 =	*IS 2.5.1*	≈	*7.1.2*
R_7 =	*IS 2.5.3*	≈	*7.1.3*
R_8 =	*SP 11.2.1*	≈	*9.1.2*
R_9 =	*IS 2.6.g*	≈	*8.2.2 a1)*
R_{10} =	*IS 2.6.h.1*	≈	*10.3*
R_{11} =	*IS 2.8.1*	≈	*8.4.2 a)*
R_{12} =	*IS 2.9.1*	≈	*9.3.1*
R_{13} =	*IS 6.e.1*	≈	*7.2 a), b)*
R_{14} =	*IS 8.a.1*	≈	*9.1.1*
R_{15} =	*IS 8.1.b.1*	≈	*9.1.3*
R_{16} =	*IS 8.1.c*	≈	*4.2*
R_{17} =	*IS 9.1.b*	≈	*5.1.1 f)*
R_{18} =	*IS 10.b.1*	≈	*7.1.6*
R_{19} =	*IS 10.a.1*	≈	*9.2.1*
R_{20} =	*IS 10.1.e*	≈	*8.5.6*

Source: Own research

As Table 1 shows, the approximate equivalence between ISO 9001 and SAAS 2020 requirements is written as $R_i = R_i^{ISO} \approx R_i^{SAAS}$, where R_i^{ISO} is the ISO 9001 requirement number, which application in practice is identical to the SAAS 2020 requirement number marked as R_i^{SAAS}.

Data collection for vector analysis and sample representativeness

We also divided the data collection into three phases because we have three dimensions of vector analysis. To determine significance R_i^{ISO} and R_i^{SAAS}, we interviewed the quality manager. Significance R_i^{SAAS} represents B_x, significance R_i^{ISO} represents A_x in vector analysis. To determine effectiveness R_i^{ISO} and R_i^{SAAS}, we also interviewed the quality manager. Effectiveness of quality requirement R_i^{SAAS} represents B_y, effectiveness R_i^{ISO} represents A_y in vector analysis. To determine employees' awareness of requirements R_i^{ISO} and R_i^{SAAS} we conducted a questionnaire survey. Awareness of R_i^{SAAS} is represented by B_z, awareness of R_i^{ISO} is represented by A_z in vector analysis.

Data collection was carried out from September 2021 to January 2022. A questionnaire survey took the most time to identify employee awareness. 40 employees took part. The level of representation of the sample file of employees was confirmed by the application of Pearson's chi-squared test (χ^2 – test), as is shown in Table 2. The calculation of the level of representation was done at the level of a statistical significance $\alpha = 0.05$. The expected values of theoretical distribution were achieved from the official register of higher education area available on portalvs.sk. The frequencies observed and the expected (theoretical) frequencies are shown in Table 2. The degree of freedom (k-1) is equal to 5, since there are six categories of job positions which an employee can hold.

Tab. 2. χ^2 - test due to employee's job position

	np_i		n_i		$(n_i - np_i)^2$	$(n_i - np_i)^2/np_i$
Job position	No.	%	No.	%		
Professor	58	11.37	4	10.00	1.88	0.166
Associate Professor	128	25.10	10	25.00	0.01	0.000
Assistant (PhD.)	294	57.65	24	60.00	5.54	0.096
Assistant	2	0.39	0	0.00	0.15	0.392
Lector	11	2.16	1	2.50	0.12	0.055
Researcher	17	3.33	1	2.50	0.69	0.208
Σ	510	100.00	40	100.00		**0.917**

Source: Own research

The achieved χ^2 value is lower than the critical χ^2 value at the level of statistical significance of $\alpha = 0.05$ for 5 degrees of freedom (6 - 1), which in particular presents the value of 1.140 (value in statistical tables). Since 1.140 > 0.917, we can conclude that our selected set of employees represents the basic one.

Results and discussion

a) ***Interpretation of three-dimension values for vector coordinates***

The results obtained by determining the significance, effectiveness and employees' awareness of the selected quality requirements are shown in Table 3. We would like to note that the values for employees` awareness located in columns A_z and B_z are calculated as arithmetic averages of values for all 40 employees. For other values, they are determined directly by the quality manager.

Table 3 presents the vector coordinates that are used in the ongoing vector analysis to determine conversion relevance and vector length.

Tab. 3. Values for significance, effectiveness and employees' awareness

	R_i^{ISO}			R_i^{SAAS}			Vector coordinates (B - A)		
R_i	A_x	A_y	A_z	B_x	B_y	B_z	(B_x-A_x)	(B_y-A_y)	(B_z-A_z)
R_1	5	5	4	5	4	4	0	-1	0
R_2	3	4	4	4	3	4	1	-1	0
R_3	3	5	3	3	5	3	0	0	0
R_4	3	3	2	5	4	3	2	1	1
R_5	3	4	4	3	4	4	0	0	0
R_6	4	3	2	4	4	3	0	1	1
R_7	4	3	2	4	3	2	0	0	0
R_8	5	3	4	3	3	3	-2	0	-1

R_9	3	3	2	3	3	2	0	0	0
R_{10}	4	3	4	4	3	4	0	0	0
R_{11}	4	2	4	3	3	2	-1	1	-2
R_{12}	5	2	4	5	2	4	0	0	0
R_{13}	4	3	3	5	2	4	1	-1	1
R_{14}	5	3	2	4	3	3	-1	0	1
R_{15}	4	3	2	5	3	4	1	0	2
R_{16}	5	4	4	4	4	5	-1	0	1
R_{17}	3	3	2	3	3	2	0	0	0
R_{18}	3	3	3	4	3	4	1	0	1
R_{19}	5	3	4	4	3	2	-1	0	-2
R_{20}	3	3	2	4	2	4	1	-1	2

Source: Own research

For example, interpret the values for requirement R_1. Requirement significance related to ISO 9001 (A_x) is very high, from the point of view of SAAS 2020 (B_x) is also very high, therefore both $A_x = 5$ and $B_x = 5$. The effectiveness of R_1 related to ISO 9001 is very high (A_y); in the case of SAAS 2020 (B_y) is only high. Awareness of both requirements in terms of ISO 9001 (A_z) and SAAS 2020 (B_z) is equally high. If we look at this requirement, it is defined in SAAS 2020 as follows: IS 2.1.1. The higher education institution defined and applied the policies for quality assurance as part of the strategic management of the institution. ISO 9001 defines requirement 5.2.1 a) as follows: Top management shall establish, implement and maintain a quality policy that is appropriate to the purpose and context of the organization and support its strategic direction.

The quality manager evaluated this common R_1 requirement as equally significant in terms of ISO 9001. It is more effective to apply, and employees do not know the definition of the requirements; they know how it is applied in practice, and they know their contribution to its assurance (these statements are represented by value 4).

b) ***Conversion strength and recommendations***

CS is a support tool for deciding whether the common quality requirement of both standards can be applied in the old way (preservation) or whether organizations have to innovate the processes in terms of the new standard (conversion). The final decision must always be made by the organization's top management. The values for decision-making are as follows:

- 27.71: Very strongly recommended conversion;
- [10, 27.71): Strongly recommended conversion;
- (0, 10): Consideration of conversion;
- 0: Either conversion or preservation;
- (0, -10): Consideration of preservation;
- [-10, -27.71): Strongly recommended preservation;
- -27.71: Very strongly recommended preservation.

Table 4 shows CR, VL and CS values. The key value for the decision is CS. As seen in Table 4, the highest positive values are the requirements R_4 (3.92), R_{15} (1.79) and R_{20} (1.22). For these requirements with higher positive values, a conversion should be considered. The highest negative values have requirements of R_8 (-2.91), R_{11} (-1.22) and R_{19} (-1.79), which represent preservation. Requirements run in accordance with the new QMS but in the old way so the processes can be preserved. In table 4, positive values are marked in grey and negative values in black.

Let us focus on the negative values that represent preservation. Common requirement R_8 defines that the organization shall monitor customers'' perceptions of the degree to which all their needs and expectations have been fulfilled. SP 11.2.1 of SAAS 2020 is also about obtaining relevant student feedback. Since the processes are set up well, there is no need to change them. Therefore, the SAAS 2020 requirement will be met, even if nothing in the customer satisfaction assessment changes, because it concerns students.

Tab. 4. QMS conversion relevance and QMS conversion strength

	CR	***Vector length (VL)***				***CS***
R_i	$0,6(B_x-A_x) + 0,3(B_y-A_y) + 0,1(B_z-A_z)$	$(A_x-B_x)^2$	$(A_y-B_y)^2$	$(A_z-B_z)^2$	$l(A,B)$	*CR x VL*
R_1	-0.3	0	1	0	1.00	-0.30
R_2	0.3	1	1	0	1.41	0.42
R_3	0	0	0	0	0.00	0.00
R_4	1.6	4	1	1	2.45	**3.92**
R_5	0	0	0	0	0.00	0.00
R_6	0.4	0	1	1	1.41	0.57
R_7	0	0	0	0	0.00	0.00
R_8	-1.3	4	0	1	2.24	**-2.91**
R_9	0	0	0	0	0.00	0.00
R_{10}	0	0	0	0	0.00	0.00
R_{11}	-0.50	1	1	4	2.45	**-1.22**
R_{12}	0	0	0	0	0.00	0.00
R_{13}	0.4	1	1	1	1.73	0.69
R_{14}	-0.5	1	0	1	1.41	-0.71
R_{15}	0.8	1	0	4	2.24	**1.79**
R_{16}	-0.5	1	0	1	1.41	-0.71
R_{17}	0	0	0	0	0.00	0.00
R_{18}	0.7	1	0	1	1.41	0.99
R_{19}	-0.8	1	0	4	2.24	**-1.79**
R_{20}	0.5	1	1	4	2.45	**1.22**

Source: Own research

It is similar to the requirements R_{11} and R_{19}, which application should be maintained in the organization. The values achieved are relatively low because the maximum value for conversion is 27.71, and vice versa, the maximum value for preservation is -27.71. Nevertheless, we observe that Matej Bel University has preserved processes related to the requirements of R_8, R_{11} and R_{19} in line with the vector analysis results, which is a new approach for decision-making about the QMS conversion.

Conclusion

Quality management systems are explored in the professional field, and methodological recommendations guiding modification processes related to the integration or conversion of standardized quality management systems are absent in both scientific and professional circles. The quality management system aims to solve the current issues in companies and institutions and hence, to eliminate the occurrence of different issues in the future. One of the basic principles is the continuous improvement of the quality management system, which causes the need to deal with changes related to integrating or converting new quality management systems. Therefore, the need to develop and test the methodologies becomes increasingly urgent. Although the authors' methodology is presented regarding the educational institutions, with the intention of ISO 9001 and the need for changes in the sectors related to ensuring increasingly high quality of processes in companies and the continuous improvement of quality management systems, this methodology can also be applied in the mining industry, the manufacturing sector, service sector, as well as in other sectors of the national economy.

Our research presents a new methodology for considering whether, when converting one standardized QMS to another, to preserve or to convert a requirement common for both QMSs. We presented this methodology with the example of ISO 9001 and SAAS 2020 in Slovak higher education. Our research also has limitations, which are the following:

- the methodology is applicable only to standardized QMS;
- there must be at least one common requirement for both QMSs;
- a small number of employees participated in the questionnaire survey (employees` awareness);
- the values of significance and effectiveness of the QMS requirement were determined by only one quality manager, but this is not a fundamental limitation of the proposed methodology;

What we want to emphasize is that this methodology can also be applied when two standardized QMS are integrated. It can only be partially applied to selected requirements of integrated QMSs. However, these requirements must be approximately equal. Three dimensions (significance, effectiveness and employees`

awareness) are defined, so it is easy to apply vector analysis and our methodology. Then the decision to convert or even integrate two QMSs is made easier. The objectives of this paper were to identify selected common requirements of the ISO 9001 and SAAS 2020, to define three basic dimensions of QMS conversion, to use vector analysis for quantifying conversion relevance (CR) and conversion strength (CS) and to recommend which requirement should be preserved or converted.

We have helped the organization in higher education to make a decision, and we believe that our model will help other, not only higher education institutions, integrate or convert standardized quality management systems. If you are interested in the matrix that we used in the vector analysis and what is processed in a spreadsheet, feel free to contact the corresponding author.

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