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# Continuing Education in Quality Management Systems in Peru (2015-2024): Factors Affecting Academic Performance

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## Abstract

Continuing education in management systems is essential for professionals seeking certification to ISO management system standards, which are increasingly required in various sectors, especially in the field of engineering. However, there is little evidence of the factors that influence academic performance in these training programs. This research examines the factors that determine academic performance in three programs related to ISO management systems: Quality, Environmental, Occupational Health and Safety Management Systems (ISO 9001, ISO 14001 & ISO 45001), Quality Management in Testing Laboratories (ISO/IEC 17025), and Food Safety and Quality Management (ISO 22000 & ISO 9001). For this purpose, data from 1386 students collected over a ten-year period (2015-2024) are used. An ANOVA is performed to determine the importance of the factors and subsequent tests (t-test and estimated marginal means) to identify the groups that obtained better performance. The results show that there are significant differences for teaching modality (d=0.50), gender (d=0.12), training program ($\eta p^2$=0.140), and specialty (d=0.29). In addition, the significant interaction between teaching modality and training program suggests that the impact of modality varies by program. These findings can guide improvements in curriculum design, teaching methods, and learning approaches in management systems professional education.

## Keywords

Engineering education, management systems standards, quality management systems, academic performance, continuing education.

## 1. Introduction

Engineering education is a constantly evolving field that responds to the demands of the global industry (Lu and Hao 2022; Sunthonkanokpong 2011). This suggests the need to evaluate and update the competencies required in the training of engineering professionals (Gandhi et al. 2012). Particularly, competencies in management systems based on international norms or standards, such as those developed by the International Organization for Standardization (ISO), have evolved from being a complement to becoming a main component in the engineering professional profile. Professionals must not only master theoretical aspects but also possess technical and practical competencies that enable them to implement and maintain management systems that ensure the quality of services or products in an organization (Ab Wahid and Grigg 2021). This evolution establishes challenges for training institutions that educate and specialize professionals in quality management systems, as they must continuously adapt their curricula to respond to new labor market demands (Abdulwahed et al. 2013; Azáldegui-Cardenas et al. 2023; Gumaelius et al. 2024; Marcos et al. 2020; Puertas et al. 2024).

Curricular adaptation may involve challenges for training institutions; for example, the need to update content according to new versions of ISO standards, the use of current and effective teaching methodologies, the adaptation

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of teaching modalities and learning tools to new technologies, and the development of assessments that confirm the acquisition of competencies applicable to real cases. Furthermore, institutions face the complexity of generating environments that simulate real organizational contexts, where professionals can apply their knowledge in implementing and maintaining management systems.

The prior review of the literature shows that there is no evidence available to guide the improvement of curriculum and teaching methodologies in quality management systems training. It is important that institutions have concrete data on the factors that affect the academic performance of students in these specific programs; for example, which teaching modality may be more effective or which variables (demographic such as gender and age or academic such as the student's prior specialty and training program) may condition the learning process. Therefore, longitudinal data from ten years (2015-2024) in continuing education programs in ISO management systems in Peru are analyzed to provide recommendations that can improve teaching effectiveness in this field, which is fundamental for professional training in the current context. For this study, three training programs linked to ISO standards are selected: Quality, Environmental, Occupational Health and Safety Management Systems (ISO 9001, ISO 14001 & ISO 45001), Quality Management in Testing Laboratories (ISO/IEC 17025), and Food Safety and Quality Management (ISO 22000 & ISO 9001). Likewise, the following factors are considered: student gender, student age, training program to which the student belongs, and the student's prior academic specialty.

### 1.1 Objectives

The main objective of the research is to analyze how the factors of gender, age, training program, and academic specialty determine the academic performance of students in three continuing education programs related to ISO management system standards in Peru: Quality, Environmental, Occupational Health and Safety Management Systems (ISO 9001, ISO 14001 & ISO 45001), Quality Management in Testing Laboratories (ISO/IEC 17025), and Food Safety and Quality Management (ISO 22000 & ISO 9001).

## 2. Literature Review

### 2.1 ISO management system standards

A quality management system (QMS) is a set of defined processes and responsibilities that enable the proper functioning of an organization (ISO n.d.). During recent years, organizations from different economic sectors have been implementing QMS based on international standards (Benzaquen and Narro, 2023; ISO 2025; Mander et al. 2016; Siltori et al. 2021; Ullah 2022). Therefore, the current labor market demands professionals capable of implementing and maintaining these management systems based on ISO standards. Among ISO standards, three stand out: ISO 9001:2015 (Quality management systems — Requirements), ISO 14001:2015 (Environmental management systems — Requirements with guidance for use), and ISO 45001:2018 (Occupational health and safety management systems — Requirements with guidance for use). These three ISO standards have the highest number of valid certificates issued by certification bodies (ISO 2025).

The increase in companies' need to obtain these certifications is based on market demands, regulations, customer and stakeholder requirements, and expected benefits; for example, reduction of operational costs, customer satisfaction, process improvement, among others (Bernardo et al. 2015; Benzaquen 2015; Psomas et al. 2011; Tari et al. 2012). On the other hand, the results of ISO Survey 2023 show that organizations belonging to the construction, mining, manufacturing, and engineering services sectors have the highest number of certificates in at least one of those three standards (ISO, 2025). However, there is a growing diversification of sectors that allows the integration of other professional profiles outside engineering; for example, physicians, administrators, educators, among others.

Despite the importance of competencies linked to QMS in the continuing education of engineering professionals, there is little literature on their effectiveness and the factors that influence professional academic performance, specifically in ISO standards training. The lack of research is more notable in Latin American contexts, such as Peru, where cultural, organizational, and economic factors may influence training in this area.

### 2.2 Factors in continuing engineering education

Research on factors that influence continuing engineering education reveals the importance of active and experiential methodologies, such as problem-based learning and simulations, which are effective for teaching management systems through the contextualization of abstract concepts (Baukal and Ausburn 2017). Comparative studies between teaching modalities show mixed results, suggesting that online teaching can be effective for standardized conceptual content

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(for example, ISO standards); however, it is necessary to incorporate interactive elements and continuous assessments (Baukal 2010; Bourne et al. 2005). Hybrid modality is also highlighted, which usually combines asynchronous components for theoretical foundations and synchronous components for collaborative activities and case study resolution (Linvill and Wallen 2022). Literature on gender gaps in engineering education reveals complex patterns that transcend simple academic performance differences and may extend to training transfer in organizations (Puertas et al. 2024). Recent research explores strategies to reduce these disparities through inclusive pedagogies, specific mentoring, and collaborative learning environments (Ojeda-Caicedo et al. 2022). Additionally, the current context of digitalization and Industry 4.0 establishes additional challenges that require constant curricular adaptation and the development of future skills for the effective integration of management systems in increasingly digitized environments (Azofeifa et al. 2024).

## 3. Methods

The research has a quantitative and descriptive approach. Regarding the temporality of the research, the data belong to the 2015-2024 period. The period encompasses the transition from face-to-face modality in the pre-pandemic to online modality in the post-pandemic. For the representation of academic performance, the final average of the student who passed one of the selected training programs is selected. The final average is the synthesis of the practical and theoretical evaluations that the student developed during training. For data collection, a review of academic records is employed. Information is compiled from official documents of the selected continuing education institution, such as data from final grade records of the three training programs. Then, possible typing errors, unavailable information, or the elimination of duplicate information are identified.

The population is composed of students from three training programs related to ISO management system standards in Peru during the 2015-2024 period. The final sample consists of 1,386 students, who are selected through non-probabilistic sampling. The sample was selected from the following three training programs: Quality, Environmental, Occupational Health and Safety Management Systems (QEOS), based on ISO 9001, ISO 14001 & ISO 45001 standards; Quality Management in Testing Laboratories (QMTL), based on ISO/IEC 17025 standard; and Food Safety and Quality Management (FSQM), based on ISO 22000 & ISO 9001 standards.

Regarding the research variables, the dependent variable is academic performance (final average of the student in each training program). On the other hand, the independent variables are sociodemographic and academic: teaching modality (face-to-face modality and online modality), gender (female and male), age (20-25 years, 26-30 years and 31-35 years), training program (QEOS, QMTL and FSQM) and academic specialty (engineering and non-engineering). The review of these variables is based on the review of previous studies linked to training in programs related to ISO management system standards, where it is described that factors such as modality or sociodemographic factors may affect the improvement of their training (Casalino et al. 2012; Puertas et al. 2024). Additionally, the inclusion of the academic specialty variable is highlighted. The exploration of this variable allows us to know if prior training has any effect on academic performance, since management systems have been traditionally related to engineering. However, the importance of having certifiable standards and the interdisciplinary training of professionals generates diversified profiles. The academic specialties considered in the “non-engineering” category are, to a greater extent, medical sciences and administrative sciences; to a lesser extent, social sciences are also found. The characteristics of the sample are shown in Table 1.

For the analysis, Minitab 22 statistical software was used. A five-factor analysis of variance (ANOVA) is performed to determine the significance of the independent variables. Additionally, mean tests are applied to the variables that show significance in the ANOVA results, in order to determine whether the population means differ statistically from each other. Likewise, the effect size of the factors is reported. For this purpose, partial eta squared ($\eta^2p$) and Cohen's d are used. For partial eta squared, effects are distributed as follows: small ≈ 0.01, moderate ≈ 0.06, large ≈ 0.14; while for Cohen's d, effects are distributed as follows: small ≈ 0.20; moderate ≈ 0.50; large ≈ 0.80 (Cohen, 1988). Additionally, estimated marginal means analysis is performed for the interaction between teaching modality and training program.

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Table 1. Descriptive statistics

| Factor | Category | Frequency | Percentage |
|---|---|---|---|
| Teaching modality | Face-to-Face | 633 | 45.7 |
| | Online | 753 | 54.3 |
| Gender | Male | 603 | 43.5 |
| | Female | 783 | 56.5 |
| Age | 20 – 25 years old | 198 | 14.3 |
| | 26 – 30 years old | 474 | 34.2 |
| | 31 – 35 years old | 327 | 23.6 |
| | 36 years old and older | 387 | 27.9 |
| Training program | Quality, Environmental, Occupational Health and Safety Management Systems (ISO 9001, ISO 14001 & ISO 45001) | 662 | 47.8 |
| | Quality Management in Testing Laboratories (ISO/IEC 17025) | 370 | 26.7 |
| | Food Safety and Quality Management (ISO 22000 & ISO 9001) | 354 | 25.5 |
| Specialty | Engineering | 965 | 69.6 |
| | Non-engineering | 421 | 30.4 |

## 4. Results and Discussion

First, the ANOVA results are presented. Five factors and one interaction were considered: teaching modality, gender, age, training program, academic specialty, and the interaction between teaching modality and training program. A significance value of 5% (95% confidence level) was used. As can be observed in Table 2, all factors are relevant and have an impact on academic performance, with the exception of the age factor. The interaction also showed statistically significant differences, but a small effect ($\eta^2p = 0.009$).

Table 2. ANOVA: academic performance

| Source | Sum of squares | DF | Mean squares | F-value | p-value |
|---|---|---|---|---|---|
| Teaching modality | 79.464 | 1 | 79.464 | 113.436 | <.001 |
| Gender | 4.509 | 1 | 4.509 | 6.436 | 0.011 |
| Age group | 0.262 | 3 | 0.087 | 0.125 | 0.945 |
| Training program | 157.129 | 2 | 78.564 | 112.152 | <.001 |
| Specialty | 2.908 | 1 | 2.908 | 4.152 | 0.040 |
| Teaching modality x training program | 8.494 | 2 | 4.247 | 6.062 | 0.002* |

***Note***. **DF**: degrees of freedom; *Partial eta-squared (0.009)

Table 3 shows the results of the mean tests for factors that showed significance and the effect size for each factor. It is observed that the teaching modality variable presents a statistically significant difference in academic performance and has a moderate impact (d = 0.50). The gender variable also presents a significant difference in academic performance, but has a smaller impact (d = 0.12). The training program variable presents a statistically significant difference and a large impact ($\eta^2p = 0.140$) on academic performance. Finally, the specialty variable presents a statistically significant difference in academic performance and a small impact (d=0.29). Overall, teaching modality is the factor with the greatest impact.

In Figure 1, the graphical representation of the means and their confidence intervals is observed. Regarding teaching modality, better performance is observed in the online modality, with a mean of 18.25 (SD = 0.969), in relation to the face-to-face modality, with a mean of 17.79 (SD = 0.852). In relation to gender, female students have a higher mean of 18.10 (SD = 0.912) compared to male students 17.98 (SD = 0.987).

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Table 3. Test of means

| Variable | Category | Mean | SD | p-value | Size of the effect |
|---|---|---|---|---|---|
| Teaching modality | Face-to-face | 17.79 | 0.852 | <.001 | 0.50* |
| | Online | 18.25 | 0.969 | | |
| Gender | Male | 17.98 | 0.987 | 0.028 | 0.12* |
| | Female | 18.10 | 0.912 | | |
| Training program | Quality, Environmental, Occupational Health and Safety Management Systems (QEOS) | 18.36 | 0.798 | <.001 | 0.140** |
| | Quality Management in Testing Laboratories (QMTL) | 17.52 | 1.062 | | |
| | Food Safety and Quality Management (FSQM) | 18.01 | 0.824 | | |
| Specialty | Engineering | 18.13 | 0.915 | <.001 | 0.29* |
| | Non-engineering | 17.85 | 0.989 | | |

***Note***. **SD**: Standard deviation; * Cohen's d; ** Partial eta-squared

In the case of the training program, students in the QEOS program have a higher mean of 18.36 (SD=0.798) compared to the other two programs. The result can be linked to the high female participation in the program, which agrees with the highest average mean value associated with participants of this gender.

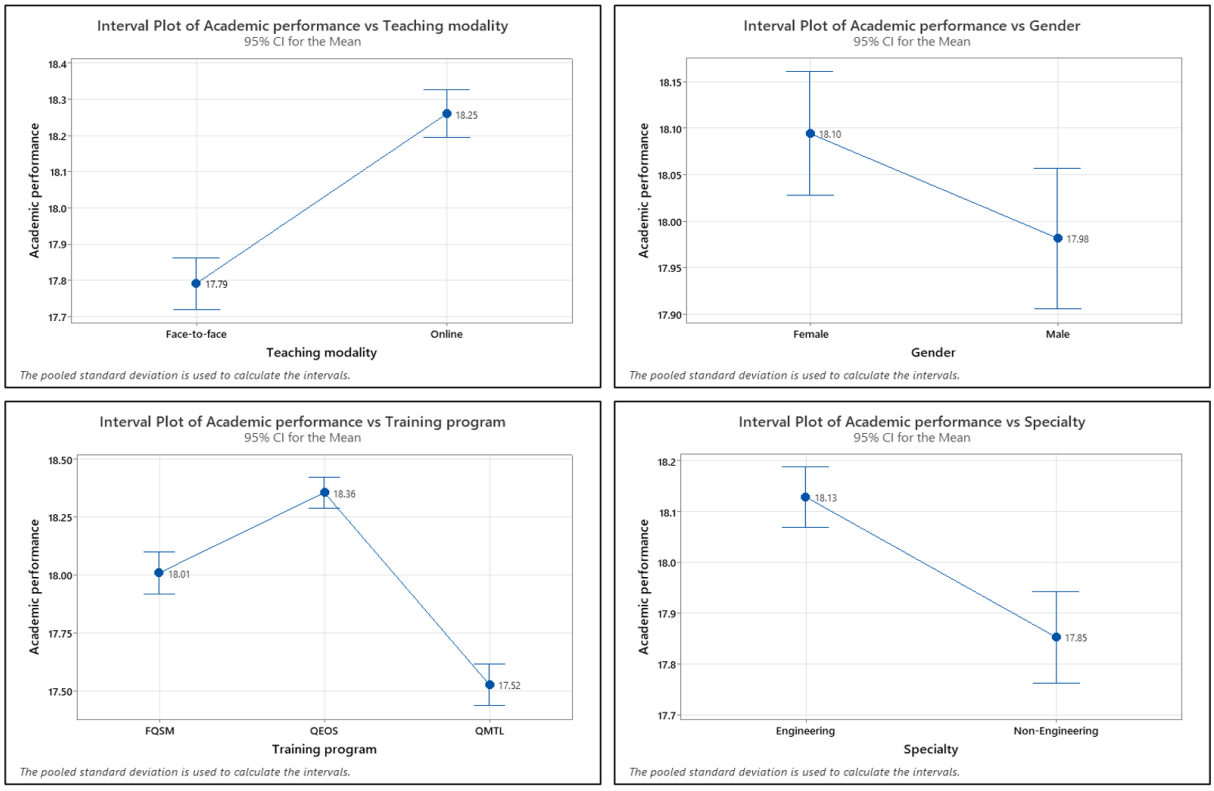


Figure 1. Boxplot of test of means: teaching modality, gender, training program and specialty

Finally, in Table 4, the results of the estimated marginal means analysis for the interaction between teaching modality and training program are observed, since it showed significance in the ANOVA. There are significant differences (p-value<0.001) between the means of students' academic performance for the 3 training programs. In Figure 2, the effect that online modality has on students' academic performance is observed with higher means than those for the face-to-face for all 3 training programs.

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Table 4. Estimated Marginal Means: teaching modality x training program

| Training program | Teaching modality | Mean (SE) | Confidence interval (95%) | Difference | p-value |
|---|---|---|---|---|---|
| Quality, Environmental, Occupational Health and Safety Management Systems | Face-to-face | 18.11 (0.042) | [17.99 - 18.18] | -0.49 | <0.001 |
| | Online | 18.60 (0.041) | [18.47 - 18.66] | | |
| Quality Management in Testing Laboratories | Face-to-face | 17.30 (0.077) | [17.16 - 17.44] | -0.37 | <0.001 |
| | Online | 17.67 (0.074) | [17.54 - 17.77] | | |
| Food Safety and Quality Management | Face-to-face | 17.56 (0.049) | [17.38 - 17.65] | -0.79 | <0.001 |
| | Online | 18.35 (0.056) | [18.18 - 18.43] | | |

***Note***. **SE**: Standard error

The highest mean of students' academic performance in online modality can be explained from the digital offering in continuing education that has allowed more active development in this modality (Area and Adell 2021; Barón and Caicedo 2021). Additionally, it is highlighted that online modality provides more facilities to continuing education students, as it represents time and cost savings for professionals with additional obligations and established job positions (Laal et al. 2014; Tejada and Ferrández 2012).

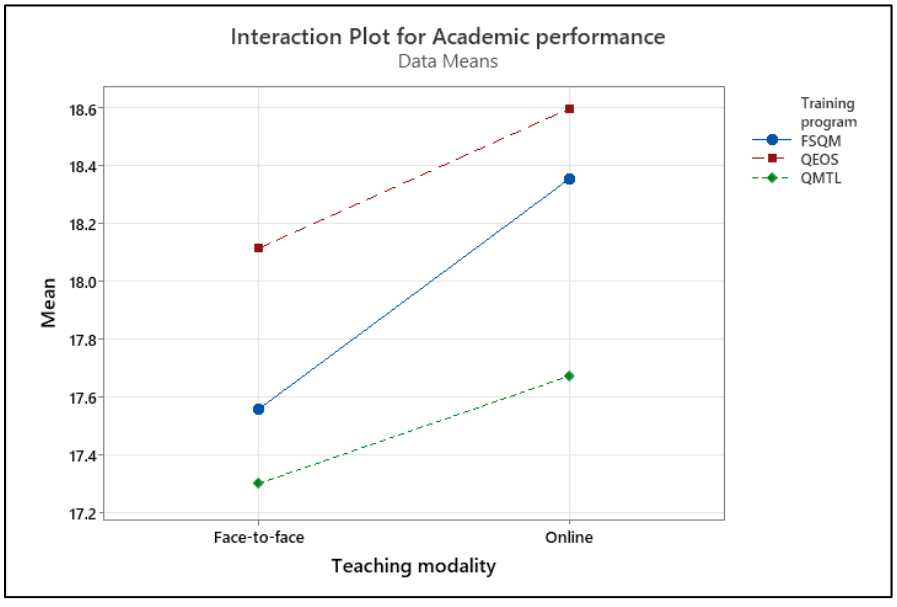


Figure 2. Line chart of estimated marginal means (teaching modality x training program)

These characteristics make online teaching modality an attractive alternative that can be more efficient for training compared to face-to-face modality. It is important to consider that beyond the advantages offered, possible gaps should be taken into account; for example, the development of sessions in inadequate environments, the digital gap in different regions of Perú, limited teacher-student interaction (Garzozi-Pincay et al. 2021), and an adequate evaluation of the students. Debate has been generated around evaluations, as they do not always represent the real learning result. For this reason, it is necessary to generate and extend participatory and collaborative environments (Picon et al. 2021) in evaluative activities of continuing education in management systems.

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In relation to the results of the gender variable, it should be considered that the sample has 56.5% female students and 43.5% male students. This context can be explained by the selected training programs. Both QMTL and FSQM usually have greater female participation due to the activities involved in their operational processes. Both programs involve professionals who usually work in microbiology, chemistry, and physical chemistry areas within the Peruvian context. Previous research reviewed in the framework of higher education presents some divergences, as in some cases the female gender presents better academic performance than the male gender (Gómez et al. 2011) and in others gender has no impact (Centeno et al. 2019; Garbanzo 2012). In this regard, it is suggested that curricula for continuing education programs in management systems should be designed according to the needs of a mixed audience that is not conditioned by gender.

Specialty, for this type of training programs linked to management systems, shows an important effect on academic performance. This can be explained, again, from the activities involved in the programs, where the participation of professionals with specialties in engineering and sciences reaches 69.9% compared to 30.4% of other specialties. In most cases, quality management training programs involve the participation of professionals with specialties in engineering and sciences due to the content of the requirements established in the reviewed standards. For example, legal, environmental, technical, safety, and risk aspects are reviewed in QEOS; aspects of measurement uncertainty estimation, validation of test methods, quality assurance, and metrological traceability in QMTL; and aspects of safety, cleanliness, and hazard analysis and critical control points in FSQM.

On the other hand, for the implementation of technical aspects and their deployment in an organization, it is required to reinforce the curricular design of management systems training programs by including activities or courses related to managerial skills. In these courses, teamwork, leadership, effective communication, conflict resolution, and change management can be included. These skills are also necessary to facilitate the implementation of the ISO management models considered in this research.

## 5. Conclusion

In this research, the proposed objective is addressed through the application of statistical analysis. Considering the Peruvian case of students from three continuing education programs related to ISO management system standards —QEOS (ISO 9001, ISO 14001 & ISO 45001), QMTL (ISO/IEC 17025), and FSQM (ISO 22000 & ISO 9001)— during the 2015-2024 period, it is identified that teaching modality has the main impact on students' academic performance. Additionally, specialty shows a significant impact and gender shows a minor impact. Conversely, age did not show significance; therefore, it can be inferred that age does not influence academic performance.

The findings allow for providing guidelines for policy formulation on continuing education in quality management systems in the Peruvian context, with potential implications for international academic debate. The differential analysis of academic performance —considering academic variables such as teaching modality, specialty, and type of training program, along with sociodemographic factors such as age and gender— offers a foundation for curricular planning and the design of optimized training interventions. The identification of differentiated response patterns to different modalities can facilitate the strategic allocation of educational resources and the implementation of personalized teaching methods. Consequently, effectiveness in competency development can be maximized.

The methodological limitations are related to the sampling restriction inherent in the single-case design. While it restricts the generalization of results, it provides a valuable exploratory approach to a phenomenon poorly documented in the specialized literature on continuing education in ISO standards. The institutional and programmatic limitation —focused on one institution and on training programs based specifically on ISO standards— constitutes another restriction that suggests the relevance of expanding the analysis toward programs with objectives different from the adequate implementation of a standard and toward training entities of diverse nature.

Furthermore, it should be mentioned that the selected factors are not the only factors that can affect the academic performance of continuing education students in ISO standards. For this reason, complementary factors could be incorporated in future studies, such as the specific professional context in which participants apply their competencies during the training process (for example, labor sector, professional experience time, among others). Finally, the focus on only final averages as a quantitative expression of academic performance is perceived as problematic; for this reason, other approaches oriented toward competency achievement should be included to perform this analysis. Despite the limitations noted, the research maintains its academic relevance by strengthening the body of knowledge

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on continuing education and quality management systems and establishing bases for scientific dialogue with subsequent research in this field.

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