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Digital skills for teachers in the Era of Education 4.0: Challenges and Opportunities in Universities

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Abstract

Education 4.0 has profoundly transformed the role of university lecturers, demanding the development of digital competencies that enable the effective integration of technologies into teaching and learning processes. This comparative, multi-country study conducted in Ecuador and Peru involved a sample of 210 university educators and employed a mixed-methods approach, combining a systematic literature review with the administration of structured surveys. The aim is to identify strengths, weaknesses, and areas for improvement in the use of digital tools, innovative methodologies, and technology-mediated teaching strategies. The findings reveal significant gaps in the use of learning management systems, videoconferencing applications, and digital assessment tools. Moreover, a lack of specialised training is evident, which limits the optimal pedagogical use of these resources. Factors such as limited access to ongoing professional development and deficiencies in technological infrastructure directly affect the effective implementation of digital education. The study concludes that educational transformation requires sustained institutional commitment to promoting continuous teacher training, ensuring equitable access to digital resources, and fostering the development of advanced digital competencies. These efforts are essential for addressing the challenges of Education 4.0 and enhancing the quality of learning in increasingly digitalised academic environments.
Keywords:

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1. Introduction

Technological advances have driven the evolution of educational processes, giving rise to what is now referred to as Education 4.0, characterised by the integration of advanced digital tools, artificial intelligence, and personalised learning environments. Within this context, teachers' digital competencies have become a central pillar in ensuring effective and adaptive teaching. However, various studies have highlighted persistent gaps in educators' digital preparedness, posing significant challenges for the implementation of innovative teaching strategies (1). UNESCO and the European Union have developed frameworks underscoring the importance of digital literacy in teacher training, emphasising that proficiency in digital tools should not focus solely on technical management, but also on their effective pedagogical application (2).

In Latin America, the adoption of educational technologies has been uneven, influenced by factors such as infrastructure, training provision, and institutional policies. While some universities have made notable progress in digitalising their programmes, others continue to face difficulties in integrating technology into teaching and learning processes (3). Moreover, the rapid evolution of digital tools requires educators to be in a state of constant professional updating in order to effectively utilise emerging technologies. In this regard, teacher training should go beyond basic ICT use, promoting active methodologies and project-based learning (4).

Likewise, in the context of Education 4.0, educators are not only facilitators of learning, but also guides in the development of students' digital competencies (5). This entails using digital resources to foster critical thinking, creativity, and problem-solving. Nonetheless, recent research has shown that many institutions still lack structured strategies to strengthen these skills among academic staff, which negatively impacts learning outcomes and institutional adaptability to new digital environments (6).

This study aims to provide evidence on the digital preparedness of university lecturers and propose recommendations to strengthen their training in a context of accelerated educational transformation. Using a mixed-methods approach, the study analyses lecturers' self-perceptions of their digital skills and the trends identified in recent academic literature. The objective is to contribute to the discussion on the urgent need for teacher training programmes that respond to the current demands of higher education in the digital age.

This study was carried out collaboratively by researchers from Ecuador and Peru, allowing for a comparative perspective between the educational realities of both countries.

2. Methods

This study employed a mixed-methods approach, combining a literature review with empirical research through surveys administered to university lecturers. The combination of these methods provided a comprehensive overview of digital competency levels among higher education teaching staff.

2.1 Research design and approach

An exploratory, sequential mixed-methods design was adopted. First, a literature review was conducted to identify models of teachers' digital competencies and their applicability to educational contexts. This was followed by a survey to assess lecturers' perceptions and levels of digital preparedness.

2.2 Documentary review

The literature review was based on the selection and analysis of studies published between 2019 and 2024, focusing on theoretical models, regulatory frameworks, and experiences of technology integration in teaching. Academic databases such as Scopus, Web of Science, and Google Scholar were consulted, applying criteria of relevance and methodological quality.

2.3 Population and sample

For the empirical phase, the target population consisted of university lecturers from various higher education institutions in Ecuador and Peru. A purposive sampling strategy was employed, selecting a sample of 210 lecturers (105 from Ecuador and 105 from Peru), ensuring sufficient representativeness to support the analysis conducted by the seven researchers involved in the study. Participants were selected based on their experience with the implementation of educational technologies in higher education institutions.

2.4 Data collection instrument

A structured survey was designed with closed-ended questions and Likert-scale items evaluating aspects such as:

• Use of learning management systems (LMS);

• Use of digital assessment tools;

• Application of innovative methodologies in digital environments;

• Perception of training in digital competencies.

In addition, open-ended questions were included to explore experiences and challenges related to the adoption of educational technologies.

2.5 Data analysis

The analysis was conducted in two phases:
• Quantitative: Descriptive statistics were used to identify patterns and trends in the adoption of educational technologies.
• Qualitative: Content analysis was applied to open-ended responses to identify emerging categories related to lecturers' perceptions of training and the use of digital tools.

2.6 Triangulation of results

Survey results were compared with findings from the literature review, allowing the identification of similarities and differences, the formulation of recommendations, and the reinforcement of digital competencies among university teaching staff.

3. Results

This section presents the results obtained from the quantitative analysis of surveys administered to university lecturers regarding their digital competencies within the context of Education 4.0. Key aspects are examined through frequency tables, including the level of adoption of technological tools, the implementation of innovative methodologies, and lecturers' perceptions of their training and institutional support in this area. These findings allow for the identification of both strengths and challenges in the integration of technology in higher education, providing a solid foundation for discussion and the development of improvement strategies.

3.1 Quantitative Results

Based on the survey conducted with 210 university lecturers, levels of digital competence were analysed across several key areas relevant to teaching within the framework of Education 4.0. The main findings are as follows:

Table 1
Use of Learning Management Systems (LMS)

Category	Absolute Frequency (n)	Relative Frequency (%)
Uses LMS platforms	172	82%
Does not use LMS platforms	38	18%
Feels competent in LMS usage	99	47%
Does not feel competent	111	53%

Note: Author's own elaboration

These results indicate that the majority of lecturers (82%) make use of learning management systems (LMS) in their teaching practice, reflecting a high level of adoption of these tools in universities across Ecuador and Peru. However, a significant proportion (53%) report not feeling sufficiently trained in their use, highlighting the need to strengthen teacher training in this area to ensure optimal implementation in both educational contexts.

Table 2
Use of Digital Assessment Tools

Digital Assessment Tools	Absolute Frequency (n)	Relative Frequency (%)
Uses Kahoot, Socrative, or Google Forms	134	64%
Uses advanced tools (automated rubrics, AI)	80	38%
Experiences difficulties in adaptation	52	25%

Note: Author's own elaboration

The data show that more than half of the surveyed lecturers (64%) use basic digital tools for formative assessment, such as Kahoot, Socrative, or Google Forms, indicating a positive trend towards the digitalisation of assessment practices in university contexts across Ecuador and Peru. However, only 38% report using more advanced tools such as automated rubrics or artificial intelligence for feedback purposes, highlighting a significant gap in the adoption of more sophisticated technologies. Additionally, 25% of lecturers indicate difficulties in adapting to these tools, reinforcing the need for context-specific training programmes in both countries.

Table 3
Application of Innovative Methodologies

Methodology Applied	Absolute Frequency (n)	Relative Frequency (%)
Flipped classroom	118	56%
Project-based learning (PBL)	86	41%
Use of AI in pedagogical strategies	63	30%

Note: Author's own elaboration

The findings show that 56% of lecturers implement the flipped classroom model in their teaching, reflecting a significant step forward in the application of active, technology-supported methodologies in higher education institutions in Ecuador and Peru. Nevertheless, the use of project-based learning (41%) and AI-driven pedagogical strategies (30%) remains relatively low, suggesting that the integration of innovative approaches within digital environments is still in the process of consolidation in many universities across both countries.

Table 4
Perception of Training in Digital Competencies

Perception of Training	Absolute Frequency (n)	Relative Frequency (%)
Considers training to be insufficient	130	62%
Interested in continuous professional development	147	70%
Has not received institutional support	**94**	**45%**

Note: Author's own elaboration

These results show that 62% of lecturers believe the training received in digital competencies is insufficient, revealing a lack of specialised preparation within higher education institutions in both Ecuador and Peru. However, 70% express interest in ongoing professional development, indicating a positive attitude towards continuous learning and pedagogical innovation in digital environments. Of concern is the fact that 45% report not having received any institutional support, highlighting the urgent need to establish institutional policies and strategies that improve training and support in digital competencies for university staff in both countries.

Table 5

Main Barriers to Technology Integration

Identified Barriers	Absolute Frequency (n)	Relative Frequency (%)
Lack of specialised training	122	58%
Limited technological infrastructure	97	46%
Resistance to change among lecturers	67	32%

Note: Author's own elaboration

The lack of specialised training is identified as the principal barrier to the integration of technology in teaching (58%), aligning with the findings reported in previous tables. Limited technological infrastructure also constitutes a major constraint (46%), potentially linked to budgetary limitations or insufficient connectivity across several universities in Ecuador and Peru. Finally, resistance to change among some lecturers (32%) suggests that institutions must foster a culture of innovation and adaptability to new technologies.

The results reveal a mixed landscape in the adoption of digital competencies within higher education across both countries. Although the use of learning platforms and basic digital assessment tools is widespread, insufficient training and a lack of specialised preparation remain key challenges. Moreover, the low uptake of advanced innovative methodologies and limited use of artificial intelligence in teaching reflect the pressing need to strengthen teacher training strategies.

Another important finding is the perceived lack of institutional support, alongside barriers such as poor infrastructure and reluctance to change. These issues should be addressed through integrated institutional policies that ensure equitable access to technology, promote ongoing training, and support lecturers in their transition towards more digitalised educational models.

In summary, Education 4.0 requires a paradigm shift in teacher education, where digital competencies go beyond technical tool usage and focus instead on pedagogical integration to enhance both teaching and learning in digital university environments.

3.2 Qualitative Results

The following section presents the literature review matrix, which compiles and synthesises key research studies related to the topic. This is followed by a detailed analysis that interprets the results, identifies trends, and highlights challenges and opportunities in the development of digital competencies among university lecturers in the context of Education 4.0.

Table 6.

Documentary Review Matrix (First 10 Entries – Translated)

#	Author	Article Title	Year	Abstract	Link
1	Reyes, D.	Digital and Technological Resources in Technical and Technological Education 4.0	2022	This study refers to digital and technological resources in Education 4.0, focusing on technical education in Ambato and identifying the characteristics of an education model based on the Fourth Industrial Revolution.	https://aulavirtual.web.ve/revista/ojs/index.php/aulavirtual/article/view/193/422
2	Torres, D., Rincón, A. &	Digital Competencies of Lecturers at Universidad	2022	The constant evolution of technology has influenced educational systems worldwide, requiring lecturers to rapidly develop	https://doi.org/10.22430/21457778.2246

	Medina, L.	de los Llanos, Colombia		new skills. This study aimed to determine the level of digital competencies of lecturers at Universidad de los Llanos and to analyse the factors influencing ICT adoption.	
3	Lorelí, A., Padilla, V., Gámiz, M. & Rómero, A.	Validation of an Interview Guide on Digital Teaching Competency in Higher Education	2019	This article presents a study to validate the content of an in-depth interview guide developed as part of a research project on the development of university lecturers' digital competence.	https://doi.org/10.17013/risti.32.1–16
4	Marzal, M. & Vivarelli, M.	The Convergence of Artificial Intelligence and Digital Competencies: A Necessary Space for Digital and Education 4.0	2024	This state-of-the-art analysis explores the convergence, then confluence, and finally symbiosis between Artificial Intelligence and Digital Competencies for Digital and Education 4.0, highlighting the complexity, challenges and opportunities through models, experiences and research lines.	https://doi.org/10.36253/jlis.it-566
5	Espinosa, J., Villamar, J., Quijije, K. & Mesa, J.	Digital Learning Ecosystems and Education 4.0: An Approach to Emerging Pedagogies	2023	This scientific article aims to explore, through a bibliometric study, the research trends related to digital learning ecosystems and Education 4.0 as an approach to emerging pedagogies.	https://doi.org/10.23857/pc.v8i9.6005
6	Roa-Banquez, K., Rojas-Torres, C. G. V., González-	Lecturers in the 4.0 Era: A Digital Training Proposal to Strengthen the Teaching and Learning Process	2021	This study validated an instrument designed to diagnose the educational use of ICTs by university lecturers, based on a digital competence model for 21st-century university teaching staff.	https://www.doi.org/10.35575/rvucn.n63a2

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7	Sifuentes, A., Sifuentes, E. & Rivera, J.	Education 4.0, Educational Modality and Comprehensive Regional Development	2022	This paper presents a critical documentary analysis of the proposal for the Education 4.0 modality, identifying its features and considering regional contexts for its implementation. It reflects on how the Education 4.0 approach should serve society comprehensively.	https://doi.org/10.33010/ie_rie_rediech.v13i0.1452
8	Lima, Z.	Revolution 4.0: New Competencies Required for Higher Education Students to Transition to Education 4.0	2021	This partial report explores the competencies higher education students must acquire to transition to Education 4.0, offering a theoretical introduction to the Fourth Industrial Revolution and the necessary evolution of higher education institutions.	https://hemeroteca.unad.edu.co/index.php/working/article/view/5438/5236
9	Mejía, L. & Osorio, J.	The New Profile of University Lecturers in Education 4.0	2023	This article describes the emerging profile of university lecturers from the Education 4.0 perspective, emphasising digital environments, continuous pedagogical updates, and innovative teaching strategies.	https://www.researchgate.net/publication/371052775
10	Arteaga, D. & Osorio, C.	Digital Competency in Education: A Systematic Review	2024	This study systematically reviews articles on digital competencies from the Scopus database between 2020 and 2024 to understand the use of ICTs in the post-COVID-19 educational context.	
	Author	Article Title	Year	Abstract	Link
11	Candia, J.	Digital Competencies in Higher Education	2023	Digital competencies enable students to critically access and evaluate information,	https://doi.org/10.33996/revistahorizontes.v7i29.612

				communicate and collaborate in virtual environments, use technological tools for learning, and solve problems creatively.	
12	Costa, J.	Education 4.0: Teaching Competencies and Skills in the Digital Era	2023	The digital era has brought numerous changes and has had a major impact on the educational landscape. Digital technologies offer new learning opportunities but also demand that students acquire new skills and abilities.	https://www.uticvirtual.edu.py/revista.tembikuaatyrekavo/index.php/revistas/article/download/23/26
13	Flores, L. & Melendez, C.	Digital Learning Strategies in Virtual Educational Environments	2024	The digitalisation of education has fundamentally changed teaching and learning processes, and especially the role of the teacher.	https://doi.org/10.35622/j.rie.2024.02.001
14	García, O.	Education 4.0 in the University Context: A Systematic Literature Review	2024	Education 4.0 represents an emerging paradigm in higher education, oriented towards technological innovation and the integration of advanced digital tools to transform teaching and learning models.	https://doi.org/10.36825/RITI.12.26.008
15	Sosa, M. & Palau, R.	Flipped Classroom to Acquire Digital Teaching Competency: A Didactic Experience in Higher Education	2018	Due to the influence of technology, acquiring digital and media competencies is essential, particularly for educators. The flipped classroom is one of the pedagogical models revolutionising the education field.	http://dx.doi.org/10.12795/pixelbit.2018.i52.03

16	Ramírez, M., McGreal, R. & Obiageli, J.	Complex Digital Horizons in the Future of Education 4.0: Insights from UNESCO Recommendations	2022	The constant pace of change has a global impact on all sectors of society, especially education. This article analyses the digital horizons foreseen in the future of Education 4.0 based on UNESCO's 2019 recommendations.	https://doi.org/10.5944/ried.25.2.33843
17	Muñoz, E., Velázquez, G. & Barragán, J.	Analysis of Technological Evolution towards Education 4.0 and the Virtualisation of Higher Education	2021	This article analyses the technological evolution of Education 4.0 and the concepts supporting digital higher education, along with the pedagogical and academic trends underpinning its virtualisation.	https://doi.org/10.56162/transdigital86
18	Triana, E., Reyes, T. & Triana, E.	Contributions of Education 4.0 and the Technological Toolbox to Current Educational Demands	2023	The technological changes of the Fourth Industrial Revolution have transformed all areas—labour, education, politics—radically changing how we study, work, shop, and socialise.	http://scielo.sld.cu/scielo.php?pid=S0864-21412023000300008&script=sci_arttext&tlng=en
19	Pico, M., Viteri, J., Lozada, E. & Freire, L.	Implementation of the Education 4.0 Taxonomy: Exploration of Digital Competencies in Software Engineering Lecturers	2024	The Fourth Industrial Revolution, with its disruptive technologies such as AI, hyperconnectivity, and Big Data, demands that individuals use these tools to optimise processes—a necessity that is mirrored in the education sector.	https://dilemascontemporaneoseducacionpoliticayvalores.com/index.php/dilemas/article/view/4125/4020
20	Sandoval, N., Acevedo, N. &	Guidelines from Industry 4.0 to Education 4.0: The IoT	2022	Industry 4.0 technologies in university environments open new possibilities for	https://doi.org/10.24054/rcta.v1i39.1379

Santos, L.	Technology Case	applications and services, leading to scientific innovations in teaching and learning processes that facilitate the emergence of Education 4.0.

The digital transformation of higher education has introduced new demands on teaching staff, particularly in relation to the development of digital competencies that enable them to adapt to technology-mediated teaching environments. In this context, Reyes et al. (7) highlight the importance of data literacy and the integration of artificial intelligence (AI) in educational processes. The incorporation of these technologies into teaching not only optimises knowledge management but also enhances the personalisation of learning, allowing content to be tailored to the individual needs of students. However, as noted by Torres et al. (8), this process entails significant challenges, as the effective implementation of AI in university teaching depends on the training and tools available to lecturers to harness its full potential. A lack of preparation and resistance to change may hinder the adoption of such innovations, underscoring the need for targeted training programmes.

From a pedagogical perspective, the relationship between digital competencies and innovative teaching strategies has been explored in various research projects. Kim (9) argues that training in digital competencies has a significant impact on teachers' ability to implement active, student-centred methodologies. In this regard, methodologies such as the flipped classroom have gained particular relevance within Education 4.0, as they promote autonomy and active learning through the use of digital tools. López et al. (1) reinforce this view by demonstrating that the flipped classroom model not only benefits students but also encourages lecturers to improve their digital skills, as they must design interactive resources, use learning management systems, and foster collaboration through virtual environments.

Despite the clear benefits of digitalisation in education, it is essential to consider the challenges faced by lecturers during this process. The digital divide among educators with differing levels of technological experience is a major obstacle, as some still rely on traditional methods and may be reluctant to adopt new technologies. Additionally, workload pressures and the lack of institutional incentives can impede the acquisition and updating of digital competencies. To overcome these barriers, it is crucial for higher education institutions to implement continuous professional development strategies, foster learning communities among staff, and provide the necessary resources for the effective integration of technologies in the classroom.

This demonstrates that Education 4.0 requires lecturers not only to master emerging technologies but also to redefine their role in the classroom—transitioning from transmitters of information to facilitators of learning in digital environments. The evidence suggests that training in digital competencies is a key factor for the successful implementation of innovative methodologies and the integration of AI in higher education. However, it is essential that educational institutions and academic policymakers provide the necessary support for lecturers to rise to this challenge.

3.3 Triangulation of Results

The triangulation of the quantitative and qualitative results in this study enables a comprehensive understanding of the current state of digital pedagogical competencies in the era of Education 4.0. By combining data obtained from the literature review with findings from surveys and interviews, it is possible to contrast and complement the information, thus providing a more robust and well-grounded overview of the topic.

From a quantitative perspective, the results reveal general trends in the adoption and development of digital competencies among university lecturers, highlighting varying levels of proficiency in technological tools, innovative methodologies, and pedagogical strategies mediated by artificial intelligence and other emerging technologies. These data help to identify patterns and correlations, such as the relationship between ICT training and the implementation of more dynamic and interactive teaching strategies.

On the other hand, the qualitative analysis, based on interviews and documentary review, provides deeper insight into lecturers' perceptions, barriers, and opportunities encountered during the transition to Education 4.0. Notable concerns include resistance to change, a lack of specific training in digital tools, and the need for institutional policies that support the effective integration of technology into teaching and learning processes. Additionally, the analysis highlights successful experiences and innovative strategies implemented across various higher

education institutions that have contributed to enhancing educational quality through the appropriate use of technology.

The triangulation of these findings confirms that, although there is a growing trend towards the digitalisation of education, significant challenges remain and require focused attention—such as continuous professional development for lecturers, equitable access to technology, and the creation of regulatory frameworks that support educational transformation. In this regard, the combination of both methodological approaches not only strengthens the validity of the results but also provides a holistic and contextually relevant perspective on current digital teaching competencies.

4. Discussion

The analysis of the data obtained in this research highlights the crucial role played by digital pedagogical competencies in the context of Education 4.0. The triangulation of quantitative and qualitative results shows that, although university lecturers in Ecuador and Peru have made progress in integrating technological tools into their teaching practices, significant challenges remain regarding training, infrastructure, and adaptation to rapidly evolving digital learning environments.

Authors such as Marzal and Vivarelli (10) argue that digital transformation in higher education requires a fundamental rethinking of teaching strategies, fostering hybrid and innovative models. The findings of this study support that view: the quantitative data from the 210 participating lecturers indicate widespread use of digital tools in their courses, yet many do not feel sufficiently prepared to make optimal pedagogical use of them. In this regard, Espinosa (11) underscores the importance of continuous training in digital competencies, a concern also expressed in the qualitative responses, where many participants emphasised the need for structured, ongoing professional development to improve their performance in virtual environments.

Moreover, the literature review reveals that artificial intelligence and learning analytics are revolutionising higher education (12). However, our findings suggest that the implementation of these technologies remains limited across many institutions, mainly due to a lack of specialised knowledge among lecturers. This aligns with the view of Sifuentes (13), who stresses that the integration of AI into teaching and learning processes requires not only a shift in mindset but also the development of new pedagogical strategies adapted to technological advances.

Previous studies have also identified institutional barriers that hinder the transition to Education 4.0, including resistance to change and inadequate technological infrastructure (14). In our study, a significant proportion of the 210 lecturers reported that institutional policies are not aligned with the demands of digital education, limiting the potential for innovation in teaching methodologies. Qualitative insights further indicate that while many lecturers recognise the value of technology, they require greater institutional support to implement it effectively.

In terms of opportunities, the results show that lecturers with stronger digital literacy have successfully integrated tools such as simulators, adaptive learning platforms, and collaborative online tools. This is consistent with the findings of Mejía and Osorio (15), who suggest that the success of Education 4.0 is closely linked to the digital fluency and pedagogical creativity of academic staff.

The contrast between the findings of this study and previous research confirms that the development of digital competencies in university teaching is a key factor in transforming educational processes in the digital age. However, the success of this transformation will depend on the implementation of comprehensive training strategies, equitable access to advanced technologies, and sustained institutional support for adopting innovative pedagogical approaches.

5. Conclusions

The results of this research confirm that digital pedagogical competencies are essential for consolidating Education 4.0, in which technology becomes a central pillar of teaching and learning. The triangulated findings from 210 university lecturers in Ecuador and Peru demonstrate that, despite notable advances in the integration of digital tools in higher education, substantial challenges remain in terms of teacher training, infrastructure, and the effective adoption of innovative methodologies.

The literature review reveals broad consensus among scholars on the need for structured and ongoing training to enable lecturers to develop advanced digital skills. These competencies are vital for the successful integration of emerging technologies such as artificial intelligence, learning analytics, and hybrid learning environments. However, the findings of this study also indicate that such strategies are still implemented unevenly or insufficiently across many institutions, due in large part to institutional barriers, resistance to change, and inadequate access to technological resources.

This study further highlights that lecturers who have achieved a higher level of digital literacy have managed to transform their teaching practices. They incorporate interactive tools, adaptive learning platforms, and active

methodologies that enhance the personalisation of the educational process. This suggests that digital competency development not only improves teaching quality but also promotes student autonomy and active engagement in the learning process.

It is therefore evident that the development and reinforcement of digital competencies among lecturers is an unavoidable challenge for higher education institutions operating in the context of Education 4.0. To ensure the effective integration of technology into teaching and learning processes, it is essential to implement institutional policies that promote sustained teacher training, guarantee equitable access to digital tools, and foster a culture of pedagogical innovation. Only through these collective efforts can we consolidate an educational model capable of responding to 21st-century demands and preparing students to meet the challenges of an increasingly digital world.

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