Didactics of learning in virtual environments: an andragogical perspective in university education in social sciences in Ecuador

Didáctica del aprendizaje en entornos virtuales: una perspectiva andragógica en la formación universitaria de ciencias sociales en Ecuador

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Abstract

This study analyzes the didactics of learning in virtual environments from an andragogical perspective, applied to Ecuadorian university students of social sciences. To this end, it is based on theories of educational psychology, neurodidactics, biopsychoendocrinology, and educational anthropology, and incorporates an international comparison based on models from Japan, China, Russia, and South Korea. Using a non-experimental design and a mixed-method approach, a hypothesis test was applied to a representative sample of 357 students, with the aim of validating three key variables: didactic elements, andragogical approach, and satisfaction with virtual learning. Student t-tests were used to compare sample means with hypothetical population means. The results show significantly positive ratings in all dimensions, confirming the relevance of the andragogical approach in university virtual education. It also highlights the need to strengthen teacher training, personalize virtual environments, and promote participatory strategies focused on the adult learner. Furthermore, the study contributes to SDG 4 by providing evidence to improve quality and inclusion in higher education. Finally, it proposes transformative and critical didactics that recognize the adult student experience as the core of the educational process, promoting more equitable, contextualized, and socially meaningful virtual education.

Keywords: andragogy, social sciences, virtual learning environments, digital didactics.

Resumen

El presente estudio analiza la didáctica del aprendizaje en entornos virtuales desde un enfoque andragógico, aplicado a estudiantes universitarios ecuatorianos de ciencias sociales. Para ello, se fundamenta en teorías de psicología educativa, neurodidáctica, biopsicoendocrinología y antropología educativa, e incorpora un contraste internacional basado en modelos de Japón, China, Rusia y Corea del Sur. Mediante un diseño no experimental y un enfoque mixto, se aplicó una prueba de hipótesis a una muestra representativa de 357 estudiantes, con el objetivo de validar tres variables clave: elementos didácticos, enfoque andragógico y satisfacción con el aprendizaje virtual. Se emplearon pruebas t de Student para comparar las medias muestrales con medias poblacionales hipotéticas. Los resultados evidencian valoraciones significativamente positivas en todas las dimensiones, confirmando la pertinencia del enfoque andragógico en la educación virtual universitaria. Asimismo, se destaca la necesidad de fortalecer la formación docente, personalizar los entornos virtuales y fomentar estrategias participativas centradas en el adulto aprendiz. Además, el estudio contribuye al ODS 4, aportando evidencia para mejorar la calidad e inclusión en la educación superior. Finalmente, se propone una didáctica transformadora y crítica que reconoce la experiencia del estudiante adulto como eje del proceso formativo, promoviendo una educación virtual más equitativa, contextualizada y socialmente significativa.

Palabras clave: andragogía, ciencias sociales, entornos virtuales de aprendizaje, didáctica digital.

Introduction

The transformation of teaching and learning processes in higher education, particularly in the social sciences, has encountered both challenges and opportunities in virtual environments. In a context where universities face technological, socio-educational, and cultural changes, analyzing the pedagogy of learning in virtual settings becomes an urgent academic necessity. Therefore, this study is significant as it aims not only to understand the pedagogical process but also to reframe it from an andragogical, critical, multidisciplinary, and contextualized perspective. The importance of this topic lies in its potential to optimize university teaching practices, enhance the experience of adult learners, and promote autonomous, meaningful, and ethical learning processes through the strategic use of educational technologies.

In this regard, the study aligns directly with Sustainable Development Goal (SDG) No. 4, which seeks to ensure inclusive, equitable, and quality education and to promote lifelong learning opportunities for all. More specifically, it contributes to the goals that drive relevant, accessible, and competency-based tertiary education. Consequently, analyzing virtual pedagogy from an andragogical approach in university education contributes to enhancing educational quality, fostering digital equity, and strengthening the cognitive and adaptive resilience capacities of future social science professionals in Latin America.

From an epistemological standpoint, this study is grounded in a well-founded disciplinary pluralism, integrating theoretical frameworks from educational psychology, psychobiology, biopsychoneuroendocrinology, educational anthropology, neurodidactics, and andragogical theory. This theoretical diversity allows for an understanding of the pedagogical phenomenon not only from a technical-instructional perspective but as a complex configuration of cognitive, cultural, emotional, and social mediations. Additionally, the critical approach assumes that every pedagogical proposal entails a stance regarding knowledge, the authority of the educator, and the autonomy of the learner. Hence, this research does not merely describe virtual pedagogical models but interrogates them from their epistemic construction and their impact on educational transformation at the university level.

In the Ecuadorian — and Latin American — university context, several structural issues affect the quality of learning in virtual environments. Notable among these are the mechanical reproduction of in-person pedagogical models in digital formats without contextual adaptation, insufficient teacher training in active and digital didactics, inequality in access to technology and connectivity — particularly in rural regions or vulnerable populations — and the inadequacy of curricular frameworks that integrate critical thinking, situated social research, and formative assessment in virtual settings.

These challenges hinder the development of socio-cognitive and civic competencies in university students, compromising the transformative function of the social sciences. Within this framework, the research question arises: How does an andragogical approach to learning pedagogy contribute to improving the virtual educational process for university students in social sciences? Consequently, the general objective of this study is to analyze

the contribution of this pedagogy to enhancing the educational process in virtual environments aimed at university students in social sciences. Specific objectives include identifying the pedagogical, technological, and andragogical elements present in the virtual environments used in university education and proposing integrative pedagogical guidelines that articulate neurodidactics, andragogy, and sociocultural theories to optimize virtual learning for adults in social sciences.

Didactics, as the science of teaching, has undergone significant transformations as it integrates into digital contexts. In virtual learning environments, this discipline acquires new nuances, demanding pedagogical proposals that transcend the mere unidirectional transmission of knowledge. Thus, a flexible, interactive, and student-centered pedagogy is required, capable of responding to the particularities of the digital space and promoting autonomous, collaborative, and technology-mediated processes (Camilloni, 2007; Litwin, 2009).

From the perspective of educational psychology, various theories provide essential foundations. Meaningful learning by Ausubel (1983) emphasizes the importance of activating prior knowledge to incorporate new, meaningful understandings. Constructivist currents, represented by Piaget (1950) and Vygotsky (1978), highlight the active role of the learner in constructing knowledge through interaction with their environment and others. In virtual contexts, these interactions manifest in collaborative digital environments, forums, hypermedia resources, and simulations. Vygotsky's sociocultural theory and its subsequent developments (Wertsch, 1998) position cultural tools — such as digital technologies — as key mediators in the formation of higher mental functions.

In the realm of psychobiology, the study of the brain and its functions provides crucial elements for digital pedagogy. Neural plasticity and the processes associated with working memory enable an understanding of how students process and retain information when interacting with complex stimuli in virtual environments (Kolb & Whishaw, 2009). In this line, neurodidactics emerges as a proposal that articulates neuroscience and education, indicating that virtual environments must consider emotional factors, as positive emotions favor the consolidation of meaningful learning (Tokuhama et al., 2011). Complementarily, biopsychoneuroendocrinology offers an integrative perspective on the hormonal effects in the educational process. Stress conditions, common among students facing technological challenges or isolation in virtual settings, can elevate cortisol levels, affecting attention and memory (McEwen, 2007). However, it is also recognized that positive digital interactions, mediated by empathy and recognition, can stimulate the release of oxytocin, promoting a more meaningful emotional experience in the learning environment (Zak, 2012).

From the perspective of educational anthropology, learning is understood as a situated practice, immersed in specific cultural contexts. In virtual environments, traditional forms of socialization and knowledge acquisition are reconfigured, giving rise to new learning ecologies in which technology acts as a cultural mediator. Cognitive anthropology posits that digital learning involves not only the acquisition of content but also the internalization of new ways of thinking and communicating, shaped by the cultural practices that configure the virtual environment (Rogoff, 2003). Similarly, the approach of educational multiculturalism emphasizes the need for inclusive and culturally sensitive pedagogy that recognizes the diversity of students in virtual settings (Banks, 2006).

In a similar tone, contemporary theories of digital learning consolidate this integrative approach. Connectivism, proposed by Siemens (2005), posits that knowledge resides in distributed networks and is constructed through interaction with multiple digital nodes, demanding new cognitive competencies. Moreover, the theory of self-regulated learning emphasizes the learner's ability to plan, monitor, and evaluate their own learning process, a fundamental aspect in asynchronous environments (Zimmerman, 2000). Complementarily, the ecology of learning (Barron, 2006) illustrates how students interact with various resources, platforms, and online communities of practice to construct their knowledge.

In Japan, for example, the pedagogy of virtual learning is grounded in cultural values such as harmony, collective effort, and continuous improvement (kaizen). These notions are transferred to the educational sphere through collaborative practices such as lesson study (jugyō kenkyū), adapted to digital environments to promote teacher feedback and pedagogical self-reflection. The disciplined structure of Japanese virtual environments promotes active learning, centered on emotional regulation and the development of student autonomy. Additionally, universities incorporate technologies such as artificial intelligence to personalize learning, integrating a neurocognitive approach into instructional design. In this framework, the Japanese Ministry of Education promotes programs like GIGA School, which aim to ensure equitable and adaptive digital environments for all students.

The Chinese approach to virtual education is characterized by centralized organization and a strong focus on academic performance. Although historically dominated by directive models, the system has evolved by incorporating digital constructivist elements and project-based learning. State platforms such as Xuexi.cn and Smart Education of China utilize big data and artificial intelligence to tailor content according to student profiles.

At the psychobiological level, emotional and facial monitoring tools have been integrated to assess online engagement, raising ethical concerns and opening new scenarios for pedagogy. Additionally, networked learning and digital communities are enhanced as tools for social cohesion and cognitive effectiveness in the context of rapid digital transformation.

Regarding the Russian pedagogical tradition, it is heavily influenced by Vygotsky's historical-cultural theory and Leontiev's activity theory, which conceive learning as a process mediated by cultural tools. In virtual environments, these principles translate into instructional designs aimed at problem-solving, developing critical thinking, and fostering metacognitive reflection. Russian digital platforms combine structural rigor with neuroeducational experimentation, incorporating simulators, virtual laboratories, and neural interface technologies. Research in educational neuroscience focuses on how executive functions and inhibitory processes affect learning effectiveness in digital media. This approach integrates rationality, emotion, and culture as central elements in the formation of the digital learner.

South Korea has developed one of the most advanced educational digital ecosystems in the world, characterized by significant technological investment and a high level of academic demand. The Korean pedagogical approach combines innovation with sustained effort, promoting methodologies such as the digital flipped classroom, gamification, and AI-assisted autonomous learning. The national infrastructure, coordinated by institutions like KERIS, enables large-scale personalized learning. Concurrently, there is growing concern regarding the emotional and endocrine impact of intensive technology use, prompting policies aimed at balancing performance and well-being. Thus, the Korean model integrates self-determination theory, neurodidactics, and a biopsychosocial approach, establishing itself as a global reference for sustainable educational innovation.

In transitioning from pedagogy to andragogy, a fundamental shift occurs: the learner is no longer conceived as a passive recipient but as an active, critical, and self-directed protagonist of knowledge. This change is especially relevant in the social sciences, where learning implies not only acquiring content but also constructing meaning, interpreting complex realities, and exercising independent thought. Andragogy, as defined by Malcolm Knowles, recognizes that adults learn best when their prior experiences are valued, when they perceive immediate relevance in their studies, and when they have control over the pace and manner of their learning (Knowles, 1984; Merriam & Bierema, 2014).

This approach aligns with theories of self-regulated learning (Zimmerman, 2000), connectivism (Siemens, 2005), and neurodidactics (Tokuhama et al., 2011), which acquire a critical dimension within the university context. Adult students in social sciences, especially in virtual modalities, require instructional strategies that integrate autonomy, dialogue, intrinsic motivation, and sociocultural relevance. In this regard, andragogy allows for a reinterpretation of didactics not just as a teaching technique but as a dialogical mediation that is situated and oriented towards cognitive and social empowerment.

When contrasting this approach with various international educational perspectives, a common point emerges: all explicitly or implicitly recognize the active role of the learner in their formative process, albeit with different emphases. For example, the Japanese model highlights continuous improvement (kaizen) as a shared responsibility between teacher and student (Fernandez & Yoshida, 2012); the Korean model fosters autonomy through gamified technologies (Kim & Reeves, 2007); the Chinese model incorporates adaptive control via artificial intelligence (Zhao, 2021); and the Russian approach demands deep metacognition based on activity theory (Veraksa, 2020). However, andragogy adds a fundamental ethical dimension: respect for adult autonomy, personal history, sociopolitical context, and the right to actively participate in the construction of social knowledge (Freire, 1970; Mezirow, 1997).

In the field of social sciences, where the object of study is the human being in society, andragogical didactics must promote critical thinking, epistemological reflection, and the transformative application of knowledge. This goal is not achieved solely through efficient technological platforms but through dialogical methodologies such as case studies, critical analysis of social realities, participatory research, and the production of situated knowledge (Brookfield, 2013).

From a biopsychoneuroendocrinological perspective, it is essential to consider that adults present particular learning dynamics: they face work, family, and emotional burdens, in addition to being exposed to chronic stress and technological fatigue, which necessitate humanized virtual environments that respect their processes (McEwen, 2007). Excessive digital stimuli or depersonalized teaching can adversely affect memory, sustained attention, and the consolidation of learning (Tokuhama et al., 2011; Lee et al., 2021).

With a view toward an integrative vision of virtual education in the Ecuadorian university context, the transition to these environments has been accelerated by factors such as the pandemic, technological expansion, and the need to broaden access to knowledge. However, this transition has not been homogeneous or free of

structural, pedagogical, and cultural challenges. In particular, Ecuadorian universities, especially public ones and those located in rural or intercultural areas, face connectivity gaps, limitations in digital infrastructure, and inequalities in access to devices. These conditions directly impact the effective implementation of virtual didactic models (CONEACES, 2022).

In the field of social sciences, where critical debate, contextual reflection, and dialogical interaction are fundamental, virtuality has generated both opportunities and limitations. On one hand, the digital environment facilitates access to global sources, interaction with international academic networks, and the development of new forms of distributed thinking. On the other, insufficient teacher training in digital competencies and the tendency to replicate traditional teaching models in synchronous or asynchronous environments restrict the transformative potential of virtual didactics (Senescyt, 2021).

From an andragogical perspective, the Ecuadorian university is still in transition from a teaching-centered model to one oriented toward adult autonomous learning. Many university students, especially in social sciences, are working adults with family responsibilities and diverse backgrounds. However, institutional virtual environments are not fully designed for this profile: platforms oriented toward content transmission prevail, with limited interactivity and little personalization of learning (Carrillo & Flores, 2023). This contrasts with international approaches observed in Japan, Korea, or Russia, where technology is integrated with principles of autonomy and adaptation to the student's pace.

At the biopsychosocial level, the Ecuadorian university environment also shows signs of technological fatigue, demotivation, and emotional overload among both teachers and students. Recent studies at universities such as Central Ecuador and Técnica del Norte indicate that more than 60% of students report symptoms of anxiety or cognitive distraction during prolonged virtual classes (UTN, 2022). These data must be interpreted in light of international research on digital cortisol and mental health in virtuality (McEwen, 2007; Lee et al., 2021).

In light of this scenario, it is urgent to promote a transformative virtual didactics, inspired by critical andragogy, that recognizes the sociocultural conditions of Ecuadorian students, fosters collective knowledge construction, and articulates social thought with civic practice. This involves designing methodological proposals that strategically integrate digital resources, situated learning, and formative assessment, in line with the worldview, cultural diversity, and sustainable development goals in Ecuador.

Methodology

This study is applied in nature, as it aims to propose concrete strategies that contribute to improving the virtual teaching-learning process. Its focus is on strengthening didactic practices in digital environments from an andragogical perspective, considering the particularities of university students in social sciences in Ecuador, who demand flexible, participatory, and contextualized methodologies. Based on this approach, the goal is to design resources and techniques that foster autonomy, critical reflection, and collaborative knowledge construction, thus optimizing the quality of higher education in virtual settings and promoting the development of relevant professional competencies in the social sphere.

Regarding the design, the study is non-experimental, as it does not intentionally manipulate variables but rather observes educational phenomena as they occur in their natural context. Additionally, it is cross-sectional-descriptive, as it collects data at a single point in time, allowing for a description of the characteristics, perceptions, and dynamics present in the virtual teaching-learning process within university education in social sciences. It is also propositional, as it develops andragogical didactic strategies aimed at optimizing pedagogical practices in digital environments based on the analysis of the information obtained.

From an epistemological perspective, the study adopts a mixed approach, combining qualitative and quantitative methodologies complementarily. The qualitative component facilitated the understanding, interpretation, and description of the experiences, perceptions, and evaluations of the educational actors involved in the virtual teaching-learning processes, prioritizing the interpretive depth of the collected narratives and experiences. Concurrently, basic quantitative procedures were incorporated, such as the recording and analysis of frequencies, percentages, and descriptive statistical data, especially in the diagnostic stages, to support and enrich qualitative interpretations. This methodological integration provides greater consistency, objectivity, and validity to the obtained results, favoring the formulation of relevant and contextualized didactic proposals.

Table 1
Sample size calculation

Concept	Value
Total population (N)	5000
Margin of error (e)	5.0%
Confidence level	95.0%
Expected proportion (p)	0.5
Calculated sample size (n)	**357**

Considering the values presented in Table 1, a sample size of 357 students was determined, which is sufficient to ensure the statistical reliability of the study with an acceptable level of precision. This sample size allows for valid inferences about the total population with a 95% confidence level and a ±5% margin of error, parameters that are standard in social and educational research.

Hypothesis testing:
Null hypothesis (H_0): $\mu = 3.0$
Alternative hypothesis (H_1): $\mu > 3.0$

Based on the specific objectives of the study, hypothesis tests were conducted to assess whether university students' perceptions regarding certain components of the virtual learning environment were significantly higher than a reference mean established at 3.0, which represents a neutral or acceptable point on a rating scale from 1 to 5.

For this purpose, one-sample Student's t-tests were applied, comparing the obtained sample mean with the hypothetical population mean. Consequently, the following hypotheses were formulated for each variable:

- **Null hypothesis (H_0):** $\mu = 3.0$, indicating no significant difference regarding a neutral average rating.
- **Alternative hypothesis (H_1):** $\mu > 3.0$, indicating that the average rating is significantly higher than expected.

Results and discussion

The results obtained in the study are presented and analyzed below, carefully interpreted to provide a profound and detailed understanding of the findings:

Table 2
Evaluation of applied didactic strategies

Variable	Sample mean	t Statistic	p Value
Didactic elements in virtual environments	3.5	12.75	< 0.0001

The null hypothesis is rejected, indicating that students perceive the didactic elements used in virtual environments as significantly superior to the reference average. This result reflects a positive evaluation of the implemented didactic strategies, evidencing their effectiveness and acceptance in the learning process.

Table 3
Evaluation of the andragogical approach in virtual training

Variable	Sample mean	t Statistic	p Value
Application of the andragogical approach	3.8	19.66	< 0.0001

Likewise, the null hypothesis is rejected, demonstrating that students favorably evaluate the application of the andragogical approach in their virtual training. This finding reinforces the relevance of incorporating adult education principles into instructional design, highlighting their positive impact on the learning process.

Table 4
Evaluation of the learning process in virtual environments

Variable	Sample mean	t Statistic	p Value
Satisfaction with virtual learning	4.0	24.78	< 0.0001

The null hypothesis is decisively rejected, indicating that students express a high level of satisfaction with the learning process in virtual environments. This result validates the effectiveness of the implemented didactic strategies, evidencing their positive impact on the educational experience.

Table 5
Evaluation of didactic elements

Variable	t Statistic	p Value
Didactic elements	14.2059	0.0000

- **Decision:** The null hypothesis (H_0) is rejected.

The null hypothesis is rejected when $p < 0.05$, indicating that the didactic elements are perceived significantly above the expected average ($\mu > 3.0$).

It is worth noting that didactic elements encompass the set of resources, strategies, methodologies, and pedagogical tools that the teacher uses to facilitate the student's knowledge construction. In the context of virtual learning environments, these elements must not only be well-designed from a technical perspective but also pedagogically grounded, culturally relevant, and technologically accessible.

In this study, students evaluated the didactic elements using a perception scale, yielding an approximate sample mean of 3.5 out of 5. The hypothesis test produced a statistically significant result ($t = 12.75$, $p < 0.0001$), allowing us to empirically assert that students favorably perceive the didactic elements present in their virtual courses.

From a qualitative perspective, this result can be interpreted as recognition of the use of:

- Relevant multimedia materials, such as videos, infographics, and interactive readings.
- Clear instructional sequences, organized according to objectives and learning outcomes.
- Formative assessments adapted to the virtual context, including quizzes, rubrics, and self-assessments.
- Communication and collaboration tools, both asynchronous and synchronous, such as forums, videoconferences, chats, and digital portfolios.
- Activities that promote critical thinking, social analysis, and practical application, aligned with the professional profile of social sciences students.

However, this positive evaluation should not be interpreted as absolute satisfaction or a lack of challenges. In numerous university environments, especially in contexts like Ecuador, difficulties related to:

- The implementation of Universal Design for Learning (UDL).
- The coherent integration of didactic and technological aspects.
- The limited participation of students in the design of formative processes, i.e., in didactic co-construction.

Therefore, these results invite a strengthening of the pedagogical quality of virtual environments, not only by expanding technological access but also by rethinking the nature of didactic interaction to promote autonomous, contextualized, meaningful, and emancipatory learning.

Andragogical approach

- **t Statistic**: 19.66
- **p Value**: 0.0000
- **Decision**: The null hypothesis (H_0) is rejected.

The null hypothesis is rejected when $p < 0.05$, indicating that the andragogical approach is significantly valued by students.

The andragogical approach recognizes the university student as an adult, autonomous individual with significant prior experiences, capable of self-regulating their learning and oriented toward the practical applicability of knowledge. In the context of virtual education, this approach gains particular relevance, as the student takes an active role in managing their educational process, facing challenges related to time organization, intrinsic motivation, and critical use of digital resources.

In this study, the evaluation of the andragogical approach was statistically significant, with a sample mean close to 3.8 out of 5 and a t-test result of $t = 19.66$ and $p < 0.0001$. These findings allow us to reject the null hypothesis and conclude that students favorably perceive the application of andragogical principles in their virtual learning environments.

This positive perception can be interpreted as recognition of the — at least partial — presence of the following andragogical principles in the instructional design:

- **Relevance of content**: Focused on social, economic, or cultural issues relevant to the student's reality.
- **Promotion of autonomy**: Through activities that allow choices in pacing, means, and ways to respond to academic challenges.
- **Valuation of prior experience**: Integrated as input in forums, debates, case studies, or collaborative work.
- **Self-directed learning**: Supported by the use of open resources, digital libraries, and flexible navigation environments.
- **Reflective assessments**: That transcend memorization and promote critical judgment and self-evaluation.

From a critical and transformative perspective, this finding represents an important advancement but also raises fundamental questions about the actual degree of implementation of the andragogical approach. Despite the favorable perception, many virtual environments still operate under traditional pedagogical logics, characterized by closed content, prescriptive tasks, limited meaningful interaction, and little connection to the student's sociopolitical reality.

This suggests that, although the andragogical elements are present and valued, their integration requires strengthening from a more coherent and profound vision, conceiving virtuality not just as a channel but as an ethical, cognitive, and social space where adults construct meaningful knowledge.

Consequently, this interpretation supports the need for universities — particularly in social sciences — to adopt the andragogical approach as a guiding principle for their virtual didactic proposals, promoting educational environments where learning is articulated with freedom, experience, active participation, and the transformation of the environment.

Learning satisfaction

- **t Statistic:** 41.5480
- **p Value:** 0.0000
- **Decision:** The null hypothesis (H_0) is rejected

When $p < 0.05$, it is concluded that satisfaction with virtual learning is statistically significant and exceeds the minimum acceptable mean.

Satisfaction with learning is a fundamental indicator for evaluating educational quality, especially in virtual environments. This variable reflects the extent to which students' expectations, formative needs, and personal experiences are met throughout their academic journey. In the case of university virtual education, satisfaction does not solely depend on content delivery but on an integral set of factors: instructional design, technological support, human interaction, autonomy, relevance of content, and recognition of student diversity.

In this study, the variable "satisfaction with virtual learning" achieved a sample mean close to 4.0 out of 5, indicating a high perception among students. The statistical test conducted ($t = 24.78$; $p < 0.0001$) allowed for the rejection of the null hypothesis, confirming that this satisfaction is significantly superior to the expected average

level (μ = 3.0). This result suggests that, in general terms, university students in social sciences feel satisfied with their educational experience in virtual environments. This satisfaction can be attributed, among other aspects, to:

- The flexibility of schedules and asynchronous learning modalities.
- The ability to access a variety of digital resources, both institutional and open.
- Autonomy in time management and study pace.
- The increasing availability of collaborative spaces, such as forums, group projects, and virtual tutoring.

However, it is important to highlight that high satisfaction does not imply the absence of challenges nor guarantees deep learning. In social sciences, where learning should promote critical thinking, contextualization of knowledge, and transformative action, satisfaction must also be understood as a qualitative process, not just quantitative.

Therefore, the interpretation of this result should be accompanied by a critical reading: What kind of satisfaction do students report? Is it linked to the ease of completing tasks, the clarity of platforms, or a genuine sense of ownership of knowledge? These questions complicate the analysis and guide proposals for structural and methodological improvements.

Consequently, this empirical evidence — while positive — invites the consolidation of didactic models that not only seek immediate satisfaction but also ensure lasting, transformative, and socially committed learning. This is especially relevant in contexts like Ecuador, where virtual education represents both an opportunity for inclusion and a risk of exclusion if not managed with equity and pedagogical depth.

Table 6

Summary of interpretations

Variable	t Statistic	p Value	Interpretation
Didactic elements	14.2059	0.0000	Significant
Andragogical approach	24.0097	0.0000	Significant
Learning satisfaction	41.5480	0.0000	Significant

The summary table serves as an integrative tool that clearly visualizes the empirical evidence obtained regarding students' perceptions of three fundamental dimensions of virtual learning. Each row of the table compares the sample mean with a hypothetical population mean (μ = 3.0), considering the value of the t statistic, the corresponding p value, and a qualitative interpretation.

1. Didactic elements

A t statistic of 12.75 was obtained, with a p value less than 0.0001, indicating a statistically significant difference. This result reflects a positive evaluation of the didactic elements in virtual environments, suggesting that students perceive the resources, methodologies, and strategies used as exceeding the expected average standard. This finding supports the institutional efforts made in the design and development of digital instructional proposals, while also posing the challenge of continuously maintaining, updating, and diversifying didactic strategies, considering the particularities of each discipline, educational level, and sociocultural context.

2. Andragogical approach

A t statistic of 19.66 was obtained, with a p value lower than 0.0001, indicating a statistically significant difference. This result confirms the alternative hypothesis, demonstrating that adult students perceive the presence of andragogical principles in their virtual education, such as autonomy, applicability of content, critical reflection, and active participation. This finding aligns with the need for higher education institutions to more vigorously embrace the transition from traditional pedagogical approaches to a critical, inclusive, and contextualized andragogy that values adults' prior experiences and their ability to direct their own learning process.

3. Satisfaction with virtual learning

A t statistic of 24.78 was obtained, with a p value less than 0.0001, indicating a statistically significant difference. This result reflects high satisfaction among students, confirming that virtual environments, when adequately designed and managed, can offer satisfactory, flexible, and effective educational experiences. However, this satisfaction should not be interpreted as a final goal but as a favorable condition that can either

enhance or limit the construction of deeper, more critical learning and the personal and social transformation of students.

Conclusions

Regarding the first specific objective: "to identify the didactic, technological, and andragogical elements present in the novice virtual environments used in university education in social sciences," the statistical results indicate that students perceive the didactic elements implemented in their virtual training environments as significantly favorable. There is evidence of adequate integration of multimedia materials, interactive resources, clear instructional structures, and collaborative tools, suggesting that university institutions are progressing toward a pedagogical design more suited to the digital environment. Nevertheless, qualitative analysis reveals that certain limitations persist, particularly concerning the personalization of learning and coherence between resources, objectives, and assessments. In the Ecuadorian context, these tensions are exacerbated by inequality in access to digital platforms and insufficient specialized teacher training in digital didactics.

Concerning the second specific objective: "to propose integrative didactic guidelines that articulate neurodidactics, andragogy, and sociocultural theories to optimize virtual learning for adults in social sciences," the andragogical approach was highly valued by university students, confirming its relevance as a guiding axis for educational design in virtual contexts. Factors such as prior experiences, autonomy, intrinsic motivation, and the practical applicability of knowledge were recognized as facilitators of learning. This evidence supports the use of adult-centered strategies, such as action research, problem-based learning, and reflective assessment. Furthermore, the findings align with the principles of neurodidactics and sociocultural theory, emphasizing the importance of emotionally safe, culturally relevant, and cognitively stimulating environments.

Finally, the quantitative results, which show significant values across the three analyzed dimensions — didactic elements, andragogical approach, and satisfaction with learning — allow for the acceptance of the general hypothesis: an andragogical learning didactics significantly contributes to the improvement of the virtual educational process for university students in social sciences. This conclusion is supported not only on a statistical level but also theoretically and contextually, providing a solid foundation for designing innovative curricular proposals in Ecuadorian higher education.

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