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ADAPTIVE LEARNING AND AFFECTIVE COMPUTING: TEACHING PRACTICE AND INNOVATION FOR COMPREHENSIVE TRAINING IN HIGHER EDUCATION

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ABSTRACT

The rapid integration of emerging technologies in higher education has transformed teaching practices, highlighting the need for adaptive and emotionally responsive learning environments. This study presents a systematic review and theoretical analysis focused on adaptive learning and affective computing as complementary tools to strengthen teaching practice and promote holistic student development. Through a documentary design supported by content analysis and a PRISMA-guided selection of 62 articles published between 2019 and 2024, the research identifies the theoretical foundations, methodological approaches, and emerging trends that support innovative, personalized, and emotionally safe learning environments. The results show that adaptive learning—supported by big data and artificial intelligence—facilitates instructional personalization, while affective computing allows the recognition and response to students' emotional states, enhancing engagement, motivation, and academic performance. The review also reveals the challenges that educators face, such as the need for technopedagogical training, ethical considerations, and infrastructure. Overall, the study provides the conceptual basis for the development of a didactic-technological model that integrates adaptive learning and affective computing in higher education, offering an interdisciplinary perspective to improve teaching practice and contribute to students' integral formation.

1. INTRODUCTION

Higher education is currently facing profound transformations driven by technological advances, the growing digitalization of training processes and the need to address the cognitive, emotional and socio-educational diversity of students. In a context characterized by technological acceleration and the demand for more flexible, personalized and inclusive pedagogical models, the need arises to integrate innovative approaches that improve the quality of education and strengthen comprehensive training. Technologies such as adaptive learning and affective computing are positioned, in this sense, as key tools to respond to the challenges of the 21st century and transform teaching practice in university environments.

Adaptive learning, based on the use of artificial intelligence, data analysis and intelligent digital systems, allows content, rhythms and strategies to be adjusted according to the particular needs of each student. This approach promotes differentiated teaching that recognizes individual progress, learning styles and levels of competence, favoring autonomy and academic self-regulation. On the other hand, affective computing incorporates models capable of interpreting, analyzing, and responding to the student's emotions, creating more empathetic, emotionally safe environments conducive to active and meaningful involvement. The combination of both approaches opens up the possibility of building more human, personalized and evidence-based training experiences, enhancing both student performance and well-being.

In this context, this research develops a systematic literature review and a theoretical analysis aimed at understanding how the integration of adaptive learning and affective computing can transform teaching practice in higher education. Through the analysis of 62 articles published between 2019 and 2024, theoretical foundations, emerging trends, challenges and opportunities are identified for the design of a didactic-technological model that favors educational innovation, emotional attention, personalization of learning and comprehensive training.

This theoretical framework allows not only to understand the current state of the field, but also to offer guidelines to guide future research and strengthen educational practices in university institutions.

2. DEVELOPMENT

Higher education faces significant challenges in its effort to adapt to the demands of the 21st century, characterized by rapid technological advances and the need for personalization in teaching-learning processes. In this context, it is critical that educational institutions adopt innovative pedagogical models that not only adapt to the individual needs of students, but also foster a holistic learning environment, where students feel emotionally safe.

This reflection arises from the results obtained in the advances of doctoral research whose objective is the configuration of a technological didactic model that enables the transformation of teaching practice in higher education for adaptive learning based on affective computing and emerging pedagogy. The results of the review and analysis of the scientific literature have shown that these studies not only seek to improve academic performance, but are also aimed at promoting the emotional well-being of students to achieve their comprehensive education, that is, they cover both cognitive and socio-emotional development (Sinchigalo-Martínez, Guzmán-Barcenes & Bonilla-Jurado, 2022; Cabrera & Polania, 2023).

In this framework, adaptive learning is defined as an educational approach that uses emerging technologies such as big data and artificial intelligence (AI) to personalize the learning experience, adjusting content, methods, and learning paces to the individual needs of each student (Ayeni, et al., 2024; Delgado, et.al., 2023; López, Escalera & García, 2023).

It also uses computerized systems and artificial intelligence tools that adjust educational content based on both the student's profile and progress, optimizing the educational experience in real time.

Affective computing, understood as an emerging branch of artificial intelligence, plays a relevant role in the proposed didactic-technological model by allowing educational systems to recognize and respond to students' emotions in online educational contexts (D'mello & Graesser, 2010). When these elements are combined with adaptive learning methodologies, it creates a personalized and emotionally safe learning environment that not only improves student engagement and academic performance, but also contributes to their overall well-being.

In accordance with the ideas presented and based on the literature review, it is analyzed how the implementation of technological innovations has been in real contexts, the challenges that teachers must face to design didactic strategies that promote personalized learning, in an emotionally safe environment where students can express themselves without fear of being judged or ridiculed. In addition,

they feel supported and valued; that is, that promotes emotional well-being. This includes creating an atmosphere of respect, empathy, and understanding, which are fundamental elements for both holistic development and motivation.

Similarly, personalized learning not only facilitates the integral development of students, but also improves the pedagogical and technological competencies of teachers, required for the creation of educational environments that integrate advanced technologies, such as artificial intelligence (AI) and affective computing, which promote adaptive learning.

Researchers such as Woolf (2010) and organizations such as UNESCO (2019), highlight the importance of these innovations in education, pointing out that they allow for more effective teaching focused on the individual needs of students.

The research is framed in the growing need to integrate advanced technologies in education to better understand how personalization of learning, recognition, and emotional management influence the educational process in personalized learning environments, where adaptive learning and affective computing have the potential to transform education by providing a technological foundation for educational practice (Del Puerto & Esteban, 2022; Yhya Alhafid, 2022), as well as providing elements that empower students to learn autonomously and also to be able to manage their emotions. In this sense, **the research poses the following general question**

- How can affective computing and adaptive learning be integrated into teaching practice to promote comprehensive training in higher education?

To answer this question, the results of the analysis of input theories are taken as a basis, taking into account relevant and pertinent categories, subcategories and dimensions of analysis, as well as the analysis of the mainstream literature from which the findings, emerging constructs and trends were analyzed.

In the following sections, the theoretical foundations of teaching practice, adaptive learning and affective computing will be described in detail. In addition, the research methods used in this field and the most relevant findings will be presented.

The objective of this paper is to present a systematic review and analysis of the mainstream literature, the basic theories that underpin the didactic-technological model of adaptive learning and affective computing in teaching practice.

The research work aimed to analyze the relevant study dimensions, categories and subcategories that serve as the basis for the design of a didactic-technological model, using the content analysis technique. This analysis is based on the emerging trends of the sources consulted, with the purpose of offering a theoretical and practical framework that promotes innovation as well as comprehensive training in higher education.

The methodology is based on a deductive rationalist epistemological approach, under the critical rationalist paradigm, it uses the method of formal logical analysis.

The research design is documentary, the technique used is content analysis. The instruments include matrices of literature analysis and theoretical interrelation. The data collection is carried out through a systematic content review, following the PRISMA methodology, covered 62 original articles published between 2019 and 2024 in recognized academic databases such as Web of Science, Education Source, ScienceDirect, Scopus and Google Scholar, in addition to works by experts and doctoral theses.

Each article was evaluated according to its quality, relevance and relevance to the topic investigated. The information collected was recorded in an analysis matrix that included indicators such as theoretical foundations, research methods, relevant findings, and challenges and opportunities in teaching practice.

From this matrix, the theoretical foundations of adaptive learning and affective computing were synthesized, the research methods used were analyzed, and best practices and emerging trends were identified.

After the actions described above, 30 articles were selected that met the established criteria, which serve as a basis for configuring the didactic-technological model, integrating the theoretical analysis with the empirical context.

The development and theoretical contributions of this work are based on the integration of input theories and antecedents in the subject as detailed in Table 1.

On the other hand, the contributions of antecedents related to the transformation of teaching practice, Affective Computing, Adaptive Learning, and emerging pedagogy have been taken into account. Table 2 then describes the review of the literature and its relationship with the proposed research.

Table 1: Theories of Entry into the Research Study.

Theory	Description/Contribution	Categories	Analysis dimensions by category
Sociocultural Theory Vygotsky, Lev (1978)	It emphasizes social and cultural mediation in cognitive development, facilitating the design of activities adapted to individual needs through the Zone of Proximal Development (ZPD) and scaffolding.	Transformation of teaching practice	Social Interaction, Cultural Context, and Zone of Proximal Development (ZPD)
		Adaptive Learning	Personalization of Learning, Use of technologies, collaboration and mediation.
		Affective computing	Emotional recognition, affective mediation, learning environment.
		Emerging pedagogy	Educational Innovation, Collaboration and Community, Professional Development.
		Technological didactic model	Technological integration, Interaction and mediation, Evaluation and feedback.
Meaningful Learning Ausubel (1983)	It emphasizes the connection of new knowledge with previous cognitive structures, promoting deep and effective learning.	Transformation of Teaching Practice	Connection of Prior Knowledge, Expository Teaching, Development of Concepts:
		Adaptive Learning	Connection of Prior Knowledge, Development of Concepts, Personalization of Learning, Prior Organizers, Interaction and Feedback,
Corno and Snow's Theory of Adaptive Learning (1986)	It promotes the adaptation of teaching to individual needs through advanced technologies, emphasizing self-regulation and metacognition.	Transformation of Teaching Practice	Instructional Accommodation, Professional Development
		Adaptive Learning	Personalization of Learning, Self-Regulation Assistive Technologies
		Emergent Pedagogy	Pedagogical Innovation, Interdisciplinarity, Learning Environment
		Technological Didactic Model	Instructional Design, Technology Tools, Evaluation and Monitoring
Theory of Connectivism Siemens, George (2004)	It highlights the social and connected nature of learning in the digital age, underscoring the importance of networks and technology in the construction of knowledge.	Transformation of Teaching Practice	Knowledge Networks. Technological integration, continuous training.
		-Adaptive learning	Learning Personalization, Interaction and Feedback, Learning Data Analysis.
		Emergent Pedagogy	Learning Personalization, Interaction and Feedback, Learning Data Analysis, Pedagogical Innovation, Collaboration and Social Learning, Accessibility and Equity.
		Technological didactic model	Design of Learning Environments, Human-Technology Interaction, Evaluation and Continuous Improvement.
General Systems Theory Ludwig Von Bertalanffy (1976)	It highlights the social and connected nature of learning in the digital age, underscoring the importance of networks and technology in the construction of knowledge.	Transformation of Teaching Practice	Interconnection of Components of the Educational System, Adaptability and Flexibility, Feedback and Continuous Improvement.
		Adaptive Learning	Personalization of Learning, Interaction and Dynamic Feedback. Educational Effectiveness and Outcomes
		Affective computing	Emotional Recognition and Response, Impact on the Learning Environment. Integration with Other Education Systems
		Emergent Pedagogy	Innovation and Pedagogical Experimentation, Interdisciplinarity and Technological Convergence, Scalability and Sustainability
Theory of Human Development Roger and Maslow (1967),	It considers the teaching-learning process as a complex and interdisciplinary system that integrates social, cultural, technological, and psychological factors.	Adaptive Learning	Individual adaptation, Curricular flexibility, Continuous feedback.
		Affective Computing	Emotional Recognition and Response, Emotional Interaction and Personalization, Ethics and Privacy in Affective Computing.
		Emergent Pedagogy	Pedagogical and Technological Innovation, Assessment and Measurement of Learning, Competencies of the XXI Century
Theory of Emotional Intelligence Salovey and Mayer (1990).	It emphasizes the importance of satisfying basic and psychological needs for effective learning and personal development.	Perception and Expression \Emotional	Accuracy in Identifying Emotions, Influence of Context on Emotional Perception, Emotional Communication.
		Emotional Facilitation of Thought	Emotional Impact on Decision Making, Emotions and Creativity, Emotional Stress Management.
		Emotional Regulation	Emotional Regulation Strategies, Emotional Adaptability, Development of Emotional Resilience.

Table 2: Background of the Research.

No.	Author(year)	Description/Contribution	Categories Emerging	Main trends
1	Alrosan, Alomoush, Youssef, Deif & El Gohary (2024)	It offers improved tools to monitor the well-being of health personnel, applicable in educational contexts.	Innovation in educational technology, Integration of artificial intelligence, Impact of technology on learning	Adaptive Learning, Educational Data Analytics, Competency-Based Education
2	Ariñez Castel (2023)	It addresses challenges such as inequality and lack of resources through the contextualization of technologies.	Pedagogical innovation, Project-based learning, Twenty-first century skills	Emerging Technologies, Personalization of Learning, Formative Assessment.
3	Bhutoria (2022) What the research is about:	Adapt educational technologies to the specific needs of each student.	Educational Technology, Teaching Innovation, Impact of Technology	E-learning, Digital Skills, Inclusive Education
4	Gao, Huang, Chen & Zhou (2024)	It increases the accuracy in the detection of emotions, strengthening spatial analysis.	Augmented Reality, Artificial Intelligence, Internet of Things	Gamification, Mobile Learning, Personalized Education
5	Gong, Chen & Zhang (2024)	Provides a robust approach for global applications in emotional recognition	Education 4.0, Adaptive Learning, Cognitive Neuroscience	Blockchain in education, Educational Big data, Virtual reality.
6	Goshvarpour &Goshvarpour (2024)	Add a new dimension to emotional analysis through blink patterns.	Inclusive Education, Mobile Learning, ICT in the Classroom	Educational robotics, Impact of artificial intelligence on education, Emerging technologies.
7	Hu, Chen, Yan, Xu & Cheng (2024)	Improves robustness and accuracy in emotion recognition using unlabeled data.	Competency-based education, Disruptive technologies, Educational innovation	Collaborative learning, Hybrid education, Continuous assessment.
8	Jin, Wang & Gao (2024)	It improves adaptation to different subjects and conditions, enriching emotional analysis.	Artificial intelligence, Innovation in teaching, Personalized education	EdTech, Mixed Reality, Impact of AI on Education
9	Li, Bian, Zhao, Wang & Schuller (2024)	Expands the possibilities for more accurate and robust analysis.	Affective computing, Machine learning, Human-computer interaction	Internet of Emotions, Educational Personalization, Ethics in Educational AI.
10	Lira López and Uribe López (2022)	Enhance learning through mass communication, in-depth information, interactivity, and collaboration	Higher Education, Pedagogical Innovation, Active Learning	Emerging Educational Models, Learning Assessment, Collaborative Technologies
11	Nalwaya & Pachori (2024)	It improves the representation of EEG signals, contributing to a more accurate emotional identification.	Machine Learning, Artificial Intelligence, Virtual Reality	Innovation in education, ICT in teaching, Digitalised assessment.
12	OECD (2018)	It transforms education towards an inclusive and student-centred approach.	Global Education, Educational Inclusion, Curriculum Innovation	Competencies of the 21st Century, International Assessment, Equity in Education.
13	Olvera Castillo and García Almeida (2023)	Training and teacher support to implement adaptive learning technologies.	Technology in the classroom, Digital inclusion, Impact of ICT	Digital Education, Current Educational Trends, Teacher Training.
14	Picard (2000)	Recognizes, interprets, and processes human emotions for the holistic development of students	Affective computing. Human-Computer Interaction, Emotional Interfaces	Emotions & Technology, Emotional Impact, Educational Apps
15	Raygoza (2022)	Improves academic performance and emotional well-being through adaptive strategies.	Educational Innovation, Personalized Learning, Teacher Professional Development	Disruptive technology, Gamification, Formative assessment.
16	Roldan et al. (2023)	Integrates students' academic and social-emotional development	Adaptive Learning, Artificial Intelligence, Impact of AI on Education	Emerging technologies, Personalization of learning, Continuous assessment.
17	Shemshack y Spector (2020)	Personalize the educational experience by adjusting content and activities in real-time	Inclusive education, Pedagogical innovation, Technological integration	Accessible Technologies, Personalized Learning, Formative Assessment.
18	NESCO (2019)	Improves academic performance and emotional well-being through active methodologies and advanced technologies	Global Education, Competencies of the XXI Century, Educational Inclusion	Sustainable development, ICT in education, Comprehensive evaluation
19	Virgili (2018) and Shemshack and Spector (2020)	It provides a solid theoretical framework and adaptable methodological models.	Inclusive Education, Inclusive Learning, Impact of ICT	Technology for diversity, Personalized education, Continuous training.
20	Zhou, Zhang, Fu, Zhang & Liang (2024)	It improves discrimination between emotional states, benefiting detailed analysis.	Educational innovation. Artificial intelligence, educational big data	Mobile Learning, Augmented Reality, Data-Driven Assessment

The theoretical and systematic analysis carried out underlines the importance of integrating adaptive learning and affective computing into teaching practice for higher education. These technologies allow learning to be personalized and create emotionally safe environments, improving the effectiveness of the educational process and developing emotional and social competencies.

Despite the challenges, such as the need for techno-pedagogical training and the integration of digital tools, there are promising opportunities to innovate in higher education. The adoption of an interdisciplinary vision that combines artificial intelligence, psychology, pedagogy and educational technology is essential to enrich research and apply effective emerging didactic strategies, allowing us to face challenges and improve the comprehensive education of students.

The systematic review and meta-analysis show the relevance of addressing various aspects for higher education, from the techno-pedagogical training of teachers to the identification of learning styles, cognitive profiles, cognitive abilities and emotions of students. Likewise, the need to use emerging adaptive and pedagogical educational technologies to motivate students, as well as improve teaching practice, is emphasized. Consequently, higher education must continue to adapt to the changes and challenges of the environment to train competent professionals, committed to society and sustainable development.

The transformation of teaching practice in higher education is necessary to face the challenges of the 21st century, integrating advanced technologies such as adaptive learning and affective computing. These tools personalize teaching and address both students' cognitive and emotional needs, improving educational quality by adjusting both content and methodologies to create emotionally safe learning environments.

The need to combine pedagogy, psychology, artificial intelligence and educational technology, and to support teachers through continuous training, is highlighted. Despite the technological and ethical challenges, it aims to overcome these obstacles with educational policies, investments in infrastructure and training programs. Optimistically, it is considered that these innovations can transform higher education and promote comprehensive training.

The findings of the systematic review and content analysis offer an initial vision for the configuration of a didactic-technological model in higher education. This model must be oriented towards the personalization of learning and the use of affective computing to improve teaching practice and innovate in the comprehensive training of students. The results for each of the phases are presented below:

Phase 1. Literature Collection and Selection: An exhaustive search of studies on adaptive learning and affective computing in higher education was carried out in recognized academic databases. 62 articles published between 2019 and 2024 were selected, evaluated for their quality and relevance.

Phase 2. Content Analysis: The analysis of the selected articles revealed several key trends. In adaptive learning, the importance of adapting teaching to the individual needs of students and the need for continuous feedback were highlighted. In affective computing, the use of technologies to monitor and respond to students' emotions and the need for systems that interact empathetically with them were highlighted. Regarding innovation in teaching practice, the integration of advanced technological tools and the continuous training of teachers in new technologies were identified.

Phase 3. Synthesis and discussion of results: key findings were identified to design the didactic-technological model. The model should be student-centered, personalizing learning, and implementing emotional monitoring tools. Trends include developing adaptive environments and encouraging interactivity and motivation. Opportunities to improve academic achievement and satisfaction were recognized, and challenges such as overcoming resistance to change and ensuring adequate infrastructure were noted. The review identified strategies for personalizing teaching and effective emotional monitoring systems

This study examines the effect of adaptive learning, affective computing, and the transformation of teaching practice in higher education, using both input theories, contributions from various disciplines such as pedagogy, didactics, psychology, and educational technology, as well as empirical evidence that underscores the relevance of these technologies to design innovative teaching strategies. The literature review confirms that technologies offer a solid theoretical framework and practical tools to optimize higher education.

The technological didactic model under development integrates the theoretical components of adaptive learning and affective computing, exploring the possibilities of operationalization of their central categories. This approach promises to be a valuable contribution to future research, as it aims to improve teaching strategies in the classroom, supporting the professional growth of educators and promoting the integral development of students in academic, personal and emotional areas.

It is critical to adopt an interdisciplinary vision that integrates knowledge of artificial intelligence, psychology, pedagogy, and educational technology to enrich research, while facilitating the application of effective emerging didactic strategies. Adaptive

learning and affective computing should be considered complementary tools, based on scientific evidence, that adjust to the individual needs of students, respecting their diversity to promote their integral development.

3. CONCLUSION

The systematic review and content analysis allow us to conclude that the integration of adaptive learning and affective computing is a solid way to transform teaching practice in higher education. Both technologies, when articulated from a pedagogical and emotional perspective, favor personalized educational experiences, sensitive to the progress and affective states of students, which has a positive impact on their motivation, academic performance and integral well-being. Likewise, the literature reviewed shows that emerging educational models must promote emotionally safe environments, based on interaction, continuous feedback and respect for the cognitive and emotional diversity of students.

The research also reveals significant challenges that need to be addressed: techno-pedagogical training of teachers, the need for adequate infrastructure, ethical considerations of the use of artificial intelligence, and resistance to institutional change. Despite this, relevant opportunities for educational innovation are identified, especially when combining approaches from artificial intelligence, psychology, pedagogy and educational technology.

Finally, the findings support the configuration of a didactic-technological model that articulates adaptive learning and affective computing as key tools to strengthen teaching practice and promote higher education oriented to the integral, emotional and academic development of students. This model offers a conceptual framework that can guide future research and practical applications in university contexts.

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