

**HIGHER EDUCATION TEACHERS AS AN ADAPTATIVE COMPLEX SOCIAL SYSTEM: DESIGNING A TRAINING MODEL FOR MULTIMODALITY CONSIDERING AN ANDRAGOGICAL APPROACH****<sup>1,\*</sup>Sandra Bonilla Meza and <sup>2</sup>Aida Huerta Barrientos**<sup>1</sup>Universidad Rosario Castellanos, México<sup>2</sup>Universidad Nacional Autónoma de México, MéxicoReceived 14<sup>th</sup> January 2024; Accepted 19<sup>th</sup> February 2024; Published online 29<sup>th</sup> March 2024

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**Abstract**

Design a training model, considering teachers as adult learners that integrate an Adaptive Complex Social System capable of performing in multimodal environments and systems. Qualitative-Quantitative research was done 1) Participatory Action Research with discussion groups, in-depth interviews, and questionnaire. 2) Design of an instrument to contrast the information obtained (triple-entry table). 3) Design of the conceptual model of teacher training based on the approach of Complexity Sciences from an andragogical approach. This study was conducted with the support of online and distance Education Department of a Center for Continuing Education in Social Work of a Public University in Mexico City during the period from 2022 to 2023. Fifteen teachers were involved, 10 women and 5 men with an age range between 45 and 70 years old. The main results obtained were: 30.77% of the teachers surveyed consider that they perform better in virtual environments with a mixed modality. 46% of the teachers surveyed consider that the most important thing when using technological resources is the didactic use that they can have and their ease of adaptation. 61.54% of the teachers surveyed think that they need to be strengthened in the development of technological skills. 53.85% of the teachers surveyed consider that for a training process to meet their needs, it is necessary to consider their motivations and the conditions of their environment. Based on the contrasts of the information obtained a model based on Social Complexity an andragogical approach was designed. Considering higher education and continuing education teachers as adult learners, agents of a Complex Adaptive Social System, it is possible to achieve a scientific and didactic-technological appropriation of multidisciplinary and in some cases transdisciplinary, which allows teachers to handle with the contingencies that arise when moving between different environments, systems and teaching and learning modalities. Which opens a new line of research regarding the Social Complexity approach.

**Keywords:** Adaptative Complex Social system, Andragogy, Teacher training model, Participatory Action Research.

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**INTRODUCTION**

The traditional paradigms with which the training of teachers has been approached have allowed the development of models that have presented advantages and allowed the development of both skills and competencies in teachers. However, it does not allow us to face unpredictable situations such as contingencies that change over time, which are integrated by several factors, relationships and interactions that arise within social systems, resulting in the formation of multifactorial problems. Understanding as problems the hostile or undesirable real situations for which it is required to perform actions that transform them to achieve the objectives pursued [1]. Currently, there are training models for teachers in the technological and pedagogical areas independently, but it is difficult to find training plans that achieve a link between them [2]. From the contingency period between 2020 and 2022, public institutions of higher education and continuing education in Mexico City undertook the task of reviewing their educational offerings, the way in which they integrate technologies into their organizational structure and their school culture. This integration of the face-to-face educational modality with the virtual modality in its different forms: e-learning, b-learning, m-learning, u-learning, and s-learning mediated by technologies has given rise to the Multimodal Systems of teaching and learning [3]. However, not all institutions and not all higher education and continuing education teachers had experience and/or were not fully prepared to implement multimodality in this emergency remote

teaching, which led to resistance to its implementation [4]. Multimodal education systems require the implementation of a series of didactic strategies mediated by Information and Communication Technologies (ICT). This had an impact on the traditional face-to-face schooling system and the distance or mixed modality, both in the teaching-learning processes and in the strategies, resources, tools, and infrastructure. In addition to the characteristics required by the actors involved in this modality. In current models of teacher training, based on andragogy, [5] proposes as a first step the creation of a favorable environment that allows the adult learner an atmosphere of trust in which he/she be considered throughout the process. [6] Insists on the creation of such an atmosphere and on the recognition that they have been successful in their learning. This requires a diagnosis of the learner's needs, who will become the goal to be followed. Currently, there are theoretical models of teacher training that rely on the conceptualization and effectiveness of technological, pedagogical, and content knowledge integration, which manage to integrate the concept of technology, such as the TPACK model [7] that involves the concepts of Technology, Pedagogy and Learning Content, even more so considering adult training. This model considers four main training needs for teaching: content knowledge, work knowledge, technological knowledge, and knowledge of adult learning approaches [8]. In this intervention proposal, teacher training is approached from the Complexity Sciences, due to the diversity of both formal and informational factors that affect it, dynamics and interactions that occur in the educational environment and that characterize a complex reality. The characteristics that emerge from these interactions can only be

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understood from the study of the system, not as isolated entities, which means that they are inter-definable. Teacher training needs require addressing not only the skills, competencies, conceptual, procedural, and attitudinal contents, but also integrating their relationship with the environment in which they develop, their objectives, attitudes, goals, motivations, capacities, skills, culture, their individual behavior, and their collective behavior as a system that includes the educational institution where they develop. This allows a holistic and teleological approach to a complex social system that can adapt over time [9]. With this background, the following research question arises: What does a model require to approach teacher training as a permanent, dynamic, integrated, and multidimensional process, from an integral approach in which converge, among other elements, the discipline, and its theoretical, methodological, epistemological, didactic, psychological, and social aspects, which integrate multimodality in the teaching practice beyond a period or contingency situation? The following hypothesis has been proposed: A teacher training model approached from the approach of the Sciences of Complexity based on andragogy will help teachers of higher education and continuing education to achieve a higher degree of scientific, academic, pedagogical, and technological appropriation of multimodality to implement it in the different teaching-learning modalities they face. For this purpose, our study object was defined and characterized: higher education and continuing education teachers considered as a Complex Adaptive Social System (CASS). The information for this characterization was obtained through the qualitative methodology: Participatory Action Research, because it allows the researcher to interact with the object of study to understand its reality [10]. From the characterization of the system and the theoretical references, its causal modeling and macro description have been carried out. This allowed us to determine the characteristics of the Social System in terms of global concepts to subsequently implement the micro description in terms of the current states and determine the desired states of its members in relation to their environment. The transcendence of this research lies in integrating in a teacher training model both the real needs of teachers in higher education institutions and the institutional goals and objectives as a Complex Adaptive Social System that allows us to predict their behavior before different stimuli coming from the environment and the degree of appropriation of multimodality according to these stimuli for the achievement of the desired state that favors a better teaching performance when moving in different teaching-learning environments.

## MATERIALS AND METHODS

Qualitative-quantitative methodology was conducted in three stages [11]:

### Panoramic review of the state of the art

Advanced search strategies were improved with Boolean operators and specific operators in databases specialized in Social Sciences: EBSCO, ERIC, SciELO and databases for different subjects: JSTOR, Dialnet, Science Direct, ERIC, SciELO, Scopus, as well as Google Scholar. A total of 1,180 references indexed in the EBSCO, ERIC, JSTOR, Dialnet, Scielo and Springer databases were analyzed, identifying 95 useful records. Among these useful records, those reporting the multidisciplinary and interdisciplinarity of training models,

andragogy and SSCAs are considered. From the panoramic review of these records published between 2016 and 2021 where teacher training models, it was found that: 1) 60% of the teacher training models that involve teaching practice in multimodal environments are theoretical. 2) they consider technological integration for teaching, but not a holistic integration that responds to the didactic-technological training needs of teachers. 3) models that consider both an andragogical approach and a holistic approach encourage teachers to develop techno-pedagogical skills to carry out their practice in different teaching-learning environments [12]. This motivates the proposal and practical implementation of training models based on Complexity Sciences.

### Implementation of participatory action research

The population under study were the teachers of a continuing education center of a public institution in Mexico City, who teach in classroom, online and distance education at the higher level and in continuing education. There are a total of 10 teachers, 5 male and 5 female, with an age range between 40 and 65 years old. All of them are specialists in their field. There are 5 female coordinators, all of them specialists in their field, between 60 and 70 years of age, who, in addition to teaching courses, perform administrative management activities. Working sessions were held with discussion groups to identify the different problems faced by teachers when migrating to teaching and learning environments other than face-to-face, their goals, objectives, and perception regarding their technological and didactic skills, with which the indicators and categories of analysis were established for the construction of the instruments for data collection: semi-structured interviews and an online questionnaire with closed-ended questions. It is worth mentioning that the participation was carried out anonymously with prior informed consent. These categories and subcategories of analysis were determined from the review of the information provided by the participants in the discussion's groups, the transcription of the in-depth interviews and the responses to the online questionnaire. In addition, a triple-entry table was designed as tool to contrast the information with theoretical references and previous research, where we found similarities with respect to the teacher training needs expressed by teachers in other higher education institutions [13].

### Causal model design

One of the analysis tools that has proven its effectiveness in dealing with complex situations is System Dynamics [14]. This tool analyzes the effectiveness of decision making to address a problem. For this modeling, we start from the problem to be solved and the construction of the dynamic hypothesis: a teacher training model from the approach of Complexity Sciences based on andragogy will help teachers of higher education and continuing education to achieve a higher degree of scientific, academic, pedagogical, and technological appropriation of multimodality to implement it in the different teaching-learning modalities they face. Complex systems need to be analyzed from the perspective of behavior generated by the interrelations and interactions of their components, which affect each other in such a way that they operate towards a common goal. It is necessary to broaden the understanding of each element that makes up the system and to analyze the variables and their variations that impact its behavior.

**Table 1. Definition of categories and subcategories**

Instruments for data collection Categories	Subcategories (Analysis Units)	Information provided by category
Multimodality: Educational Modalities	On-site Distance learning On-line Multimodal	Knowledge about the different educational modalities and their implementation.
Teaching/-learning Environments	Face-to-face Virtual Blended Hybrid	Perception of teacher performance in different teaching and learning environments.
Teacher training	Didactic-pedagogical skills	Percepción de necesidades de formación docente
Digital skills	Technological management	Motivación para formarse
Technological tools	Development of didactic materials Didactic planning Interest in teacher training Outstanding Sufficient Basic Deficient Didactic uses Mastery of resources Adaptability	Enfoque y modalidad de formación en que ha participado Perception of teacher training needs Motivation for training Training approach and modality in which they have participated. Teacher's perception of their digital skills Use of technological tools and resources for didactic purposes

Note. Source own elaboration.

**Table 2. Subsystems, members, and study variables of the CASS**

Subsystems	Subsystem Members	Study variables per subsystem	Concept
Coordination	Coordinator, area responsible, administrative responsible	Institutional goals and Objectives Center goals Administrative Management Logistic Technological-pedagogical dominion	Specific objectives of the institution related with the specific development plan
Instructors	Disciplinary instructors (Technology and pedagogy)	Communication Motivation Academic Management	Effective use of ICT, planning, organization, monitoring, administration, and evaluation of educational processes.
LMS	Virtual classrooms LMS administrator Programmer	Information Management Personal objectives Professional objectives Training needs Goals	User performance monitoring (evaluation). Mediation tool (resources and activities).
Teacher learners	Teachers participating in training courses	Context Technological domain Didactic domain Motivation Participation Accreditation	Set of knowledge, skills and attitudes, motivation, and self-perception regarding the mastery of technological skills.

Note. Source own elaboration.

The construction of a conceptual model of reality from the approach of the Complexity Sciences considering the systemic microanalysis that starts from the identification of the basic units of analysis or variables of study, identified from the transcription of the information obtained from the instruments used.

**Table 3. Identification of the system state variables**

Independent variables	Dependent variables
Institutional Objectives	Course definition
Institutional Goals	Logistics and planning
Center Goals	Delivery of courses
Technological proficiency (instructors)	Participation in the courses offered
Professional goals and objectives of teachers in the role of students (to what extent do they meet or achieve them)	Accreditation
Personal objective and goals of teachers in the role of students (to what extent do they meet or achieve them). achieved)	Achievement of the graduate profile
Technological mastery (teachers and students)	
Didactic expertise	

Note. Source own elaboration.

The properties of this variables can refer to the system itself and/or to the kind of interrelationships established with other members (in our case agents) of the system or with the environment, they have a certain value that can change over time and characterize the system. The systemic variables identified from the data collection devices are the following. These variables determine the internal state of the system at an indeterminate instant, they constitute its memory and order, this which is mathematically represented as the number of equations that describe it. In our case they are the minimum sufficient to allow us a macro description of the system and its behavior. The type of effects or responses produced by the system when a stimulus is applied to it depends on these state variables. And according to our hypothesis, the stimulus is the teacher training model [1]. A causal model of the system was created. The elements and environment were identified, as well as their relationships. We observe that this system satisfies the conditions that characterize a CASS: 1) its members are interrelated, the behavior of each member affects the behavior of the whole 3) the way in which the behavior of each member affects the behavior of the whole depends on at least one of the other members.

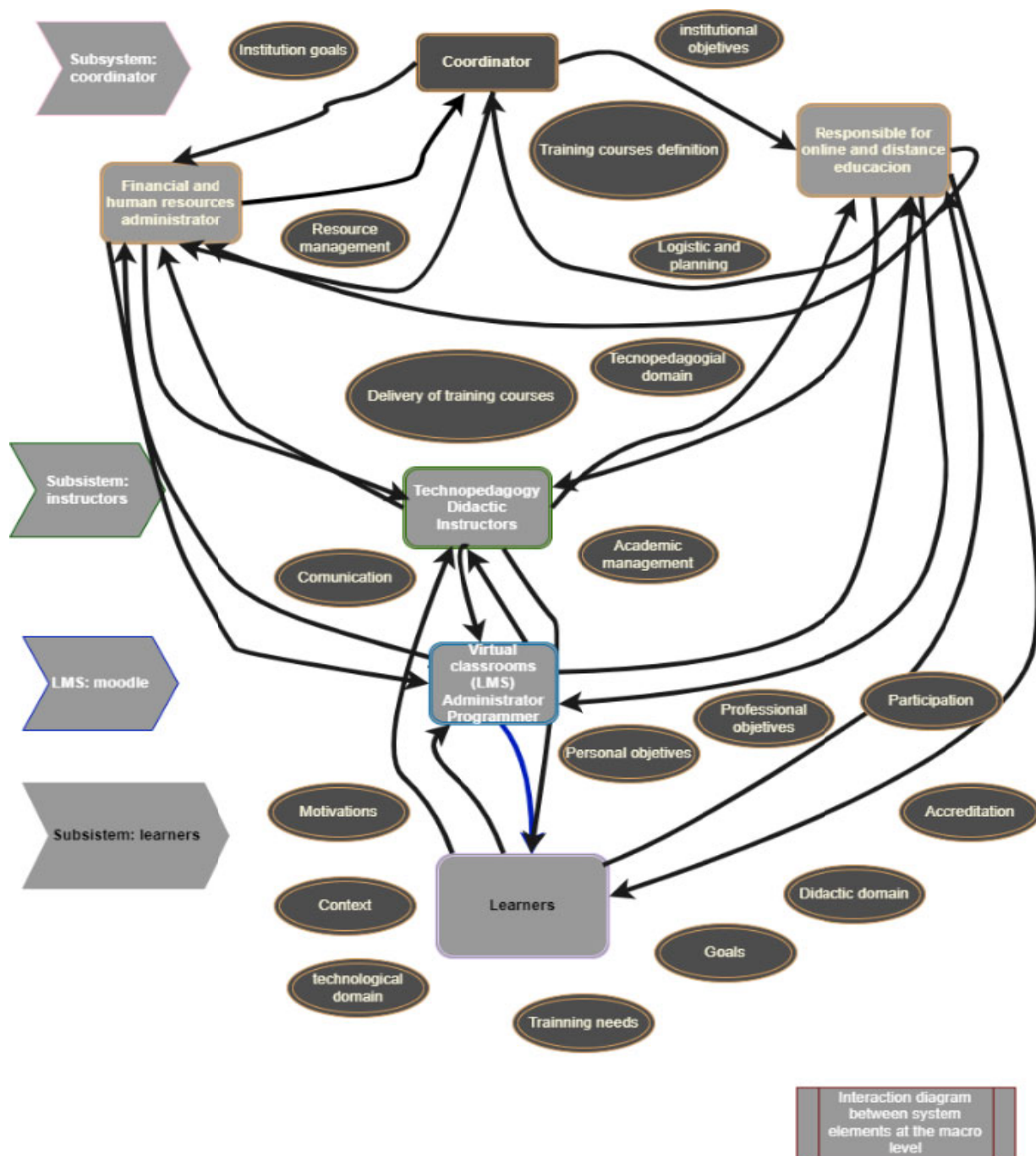


Figure 1. Causal model design. Elements interaction at macro level

In this diagram of the causal model, we identify the different state variables of the system and their influence on the relationships between the different subsystems that make up the CASS. The definition of the number and type of systemic variables in each state is one of the critical phases in the study of a system because the usefulness and reliability of the system depend on their adequate choice [15].

## RESULTS AND DISCUSSION

### Results

From the information obtained in the discussion groups, interviews and the questionnaires applied online, the findings are follows:

- 30.77% of the teachers surveyed consider that they perform better in virtual environments with a mixed modality.

- 38% of the teachers surveyed consider that they have outstanding digital skills.
- 53% of the teachers surveyed consider that they use technological tools and/or resources in all cases.
- 30% of the teachers surveyed consider that they plan their class sessions for the virtual modality.
- 46% of the teachers surveyed consider that the most important thing when using technological resources is the didactic use that they can have and their ease of adaptation.
- 61.54% of the teachers surveyed think that they need to be strengthened in the development of technological skills. This contradicts the fact that teachers perceive that they have outstanding digital skills.
- 61% of the teachers surveyed consider that their interest in participating in academic events for their teacher training is to build and apply new knowledge.
- 53.85% of the teachers surveyed consider that for a training process to meet their needs, it is necessary to consider their

motivations and the conditions of their environment. This coincides with the answers provided by the pilot group.

It was found that 61.54% of the participating teachers think that the institution does not consider their infrastructure conditions and access to technological resources. That their training needs are not being met. An area of opportunity is identified in the communication between teachers and institutions, since the institutional goals and objectives do not consider the conditions in which teachers develop in each of the different public institutions in Mexico City, which results in the lack of participation and in the number of teachers who conclude the training, qualification and/or updating processes. Moreover, teachers do not manage to improve their technodidactic performance in different teaching-learning environments, but continue to implement the same planning, strategies, and resources as in the face-to-face modality. By identifying the state variables and the interrelationships of the system, it was possible to establish the conceptual model of the present state of the CASS in accordance with the paradigm of the complexity sciences [16] as follows:

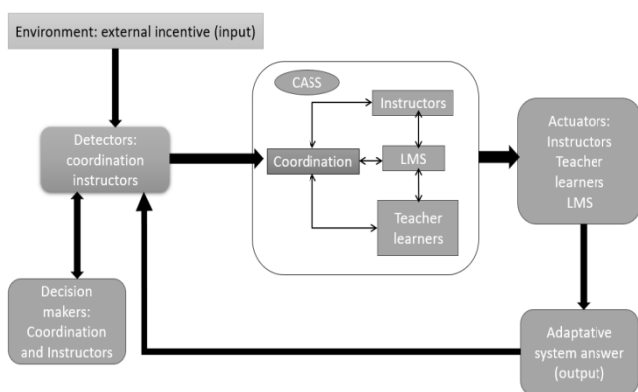


Figure 2. Present system state model

In this present system state model, is observed the importance of the different stimuli (inputs) from the environment. These stimuli have a direct bearing on the appearance of nonlinear and emergent interactions that result in different output responses of the system that are adaptive over time [17]. As [18] As states:

“...the Complex Systems research consists in proposing successive modeling until an acceptable model is reached, understood as a model that allows the formulation of causal explanations of the phenomena under study ... The set of relationships involved therein constitutes the explanation of the system's functioning” (p.84).

This coincides with the proposal to influence the CASS with different stimuli (inputs) such as the teacher training proposal aligned with the institutional objectives and goals, the different social and labor benefit policies that the institution can offer, the professionalization opportunities, the benefits of the career ladder, etc. Most importantly, the ability to move of moving between different teaching and learning environments.

## Conclusion

Although current teacher training models have integrated multidisciplinary and in some cases transdisciplinary, they do not consider the motivations, interests, objectives, and goals

of the teachers that make up the CASS and that generate both formal and informal interactions that affect their behavior and response as CASS and may affect their viability. Hence the importance and relevance of considering the approach of Complexity Sciences in the design of teacher training models, which integrate both the Holistic and Teleological points of view of this approach, where teachers are treated as adaptive agents to new interactions and part of their training process. Given that in Complex Adaptive Social Systems, interactions emerge according to the stimuli that affect them, it is necessary to know their operating rules, state variables, objectives, and goals in the present state prior to the stimulus (input). Such that it is possible to analyze the behavior of the CASS and its output response once the stimulus has been introduced, with the purpose of designing a useful and reliable model that represents the real behavior of the system in order to design the model of the desired state where both the institutional goals and objectives and those of the CASS members for the appropriation of multimodality are met.

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## Competing interests

“Authors have declared that no competing interests exist”.

## Authors' contributions

Authors may use the following wordings for this section: “Author A: Sandra Bonilla Meza’ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. ‘Author B: Aida Huerta Barrientos ’Academic and methodological advisor. All authors read and approved the final manuscript.”

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