
La teoría de la complejidad: base teórica del multigrado ***The theory of complexity: Multi-grade's theoretical base***

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Resumen: En la escuela multigrado el tratamiento a las disciplinas del currículo escolar se apoya en la interdisciplinariedad desde perspectivas didácticas. No se posee referencia de la teoría de la complejidad como base teórica del proceso pedagógico en este tipo de aulas. Se revisaron fuentes bibliográficas, se entrevistaron informantes claves, expertos, metodólogos y maestros de experiencia. Se determinó como resultado relevante que la teoría de la complejidad es un campo de estudio que muestra la realidad de la educación como fenómeno irreversible en el tiempo, inestable, de alta complejidad atendiendo a las múltiples dimensiones que coexisten en el contexto escolar multigrado.

Palabras claves: Interdisciplinariedad; Nodos cognitivos; Núcleos conceptuales comunes; Integración; Complejidad, Tarea docente.

Abstract: At the school multi-grade, the treatment to the disciplines of the school curriculum leans in the Interdisciplinarity from didactic perspectives. Reference of the theory of the complexity like theoretical basis of the pedagogic process in this type of classrooms is not possessed. They checked bibliographic sources, keys, experts, methodologists and teachers of experience interviewed informants themselves. The reality of the education like irreversible phenomenon in the time determined that as a result relevant the theory of complexity is a field of study that you show, unstable, of loud complexity attending to the multiple dimensions that they coexist in the school context multi-grade.

Keywords: Interdisciplinarity; Cognitive nodes; Conceptual common nuclei; Integration; Complexity, Teaching work.

Introduction

Complexity theory emerged in the mid-20th century as a scientific paradigm aimed at understanding the complexity of life. This paradigm provides the necessary theoretical foundation for studying highly complex objects, such as schools, without resorting to a radical reduction of them.

Interdisciplinarity is included among the categories of analysis of complex thought in the educational context. In the field of pedagogy, interdisciplinarity is viewed as a didactic strategy, a didactic principle, a methodological approach, and a means of integrating knowledge, with an emphasis on the single-classroom model in multigrade schools.

To effectively manage single-grade classrooms with multiple grade levels simultaneously, the Ministries of Education of Latin American nations developed various methodological approaches. These approaches trained teachers in multi-grade schools to identify common core content; integrate common subject areas; identify shared conceptual themes; determine interdisciplinary cognitive nodes; identify interdisciplinary nodes of common knowledge and skills; identify nodes of interdisciplinary articulation; incorporate interdisciplinary elements into teaching methods; and establish interdisciplinary relationships.

Furthermore, it is important to emphasize that all these proposals were based on didactics as a branch of pedagogy. There is no evidence that these proposals were based on complexity theory.

Therefore, this article aims to analyze some basic concepts and approaches of complexity theory that are related to pedagogy and that allow it to be considered as a theoretical basis for the teaching and learning process in multigrade schools.

Development

In the historical development of the teaching and learning process during the period of the Revolution in power (1959-2024) in Cuba, for the proper management of single classes in multi-grade classrooms, methodological work methods were designed through which the teacher of this type of classroom was trained to determine common basic contents in the period between 1994-1999. Common basic contents as a pedagogical category have been defined as “(...) the set of relevant knowledge that integrates the teaching process (...)” (García, 1998).

During this same period, other theorists referred to this methodological approach as the integration of common core courses. According to the Autonomous University of Baja California (2019), a common core course consists of a set of learning units belonging to a group of related disciplines or programs within the same area of knowledge, fostering Interdisciplinarity.

Starting in 2000, concepts related to the integration of content or subjects were adopted as a theoretical and didactic approach for teaching single classes in multigrade classrooms. Later, the term “establishment of interdisciplinary relationships” was used, referring to the search for common conceptual nuclei.

In subsequent years, the identification of interdisciplinary cognitive nodes, interdisciplinary nodes of common knowledge and skills in the teaching and learning processes of the disciplines under study, interdisciplinary articulation nodes, and interdisciplinary nodes in didactics were explored. However, all these proposals were based on didactics as a branch of pedagogy, not on complexity theory.

In the field of complexity theory, Tobón argued “(...) a model of transdisciplinary analysis of reality that allows for complexity must take into account (...) interdisciplinarity (...)” (2006, p. 91). As can be seen in this approach, there is a relationship between complexity theory and pedagogy. Different authors agree in considering interdisciplinarity as a pedagogical strategy that involves the interaction of several disciplines, understood as dialogue and collaboration between them to achieve the goal of new knowledge.

As confirmation of the above, viewed from the perspective of complexity theory, Cárdenas et al. (2004) rightly stated “Currently, complexity theory seeks to explain the universe as a whole, beyond the simple sum of its parts, and how its components come together to produce new forms.” (p. 4)

Furthermore, in conceptions adopted by other authors, the relationship between complexity theory and pedagogy is revealed. In this line of analysis, according to Colom, 2005 (cited by Galán, Ruiz-Corbella and Sánchez, 2014)

The paradigm of complexity aims to show the reality of education as it is: an irreversible phenomenon in time, highly complex, unstable, uncertain, unpredictable, not at all linear, with significant differences in its starting point, dynamic and, ultimately, chaotic (...) (p. 282).

Despite the depth and clarity of the considerations made by the previous authors, in the crucible of the analysis of the relationship between complexity theory and pedagogy, it is worth highlighting the incomparable acuity shown by Maldonado (2014, p.7) when he expressed:

In 2008, Mason published a series of texts specifically focused on the relationship between complexity and the philosophy of education, a second-order reflection. Education can and should be considered as a whole (or totality), necessarily taking into account social processes as well as ecological and cultural ones; in such a way that education ceases to be studied simply as an important and instrumental (applied) field. Interdisciplinarity emerges here with full force, not only within the social sciences and humanities, but, even better, with other sciences such as physics and chemistry, for example. (p.7)

Later, Maldonado categorically states that “(...) properly understood, education is the area where interdisciplinarity has the best place.” (2014, p.21)

In this sense, and as a way of concluding the establishment of the relationship between complexity theory and pedagogy and education, Herrada (2020, p. 26) adds that:

Relevant knowledge must recognize complex units in their multiple dimensions; just as society is made up of a historical, economic, social, and spiritual dimension, so too is man in his multiple dimensions a biological, social, psychic, affective, and rational unit. (p. 26)

Presentation of results

One hundred percent of the experts (12), practicing teachers (8), and methodologists (5) interviewed agreed that, in the actual teaching and learning process in multigrade schools, each student presents different levels of cognitive development, different levels of skill development, different levels of ability development, etc. Thus, a group of students in a single grade becomes a complex unit, a multigrade group becomes a complex of complexities, and the process of planning, directing, controlling, and evaluating the teaching and learning process becomes a complex system.

In this sense, in the multigrade school one of the main concepts of complexity theory finds its expression: complex system, which is defined by Mitchell (2009) cited by Díaz (2012, p. 8) as a system in which large networks of components without central control and with simple rules of operation give rise to complex collective behavior, sophisticated information processing and adaptation through learning or evolution.

It is generally agreed among those interviewed that individual differences exist among all members of a school group. They point out that these differences generate diversity and require teachers to tailor content to the individual characteristics of each student. Thus, it is common for students in the same grade to have low (NAB), medium (NAM), and high (NAA) levels of assimilation. However, 83.3% of the experts, 100% of the teachers, and 80% of the methodologists interviewed stated that not all teachers in multi-grade schools present learning situations that address students' individual differences and developmental levels. They emphasized that they conduct their classes in a linear fashion, with common learning tasks for all students in the grade, which negatively impacts the development of each student's potential and their progress toward a zone of proximal development.

Table 1: Assimilation levels

Assimilation Level Low	Medium Assimilation Level	High Assimilation Level
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Source : Prepared by the authors

One hundred percent of those interviewed acknowledge that, considering only the levels of assimilation, a single-grade classroom becomes a complex organization, and they express concern that, in diverse educational contexts, traditional teaching has focused on directing a flat, homogeneous, or linear teaching-learning process. They assert that teachers focus on achieving specific teaching objectives, transmitting pre-established content, developing certain skills, etc. , and present students with the same learning situations, without taking into account the different levels of assimilation or development achieved by each student.

Example:

In the area of Mathematics 2nd grade, it is a teaching objective that students master that the successor of a natural number is obtained by adding 1 to any given natural number.

By responding to the following learning situation, the teacher can measure the level of achievement of this objective:

- What is the successor of 99? Possible answer: $99+1=100$

With that possible response, the student demonstrates mastery of the objective, mastery of the content, development of the skill, and so on. Furthermore, the student's performance in fulfilling the assigned task is straightforward, as is the teacher's performance in directing and monitoring the students' work. The minimum requirements established by the curriculum are met, and both the teacher and the students experience a false sense of satisfaction. Because, whether in a single-grade or multi-grade classroom, every teacher should nurture the potential of each student.

From this analytical perspective, the previous example is a text-based exercise with a low level of depth. It is suitable for learners with low cognitive development, slow learners, or those with low assimilation levels (NAB).

According to the considerations of 100% of those interviewed, the class becomes a complex unit, taking into account that the teacher must comply with the principle of attention to diversity, a common didactic requirement for the direction of classes at all levels of teaching.

Furthermore, the interviewees acknowledge that presenting all students with the same learning situation or teaching task, at the same level of depth, biases the individual growth of each student as an entity, with notable and lasting harm to those with medium and high levels of assimilation, who are forced to learn what is pre-established in the curriculum, keeping them at the same level as the other students in the grade.

In this regard, they emphasize the need for teachers to increase the depth of learning situations, taking into account the levels of assimilation and cognitive development achieved by each student in each grade. They

point out that, indeed, the complexity becomes evident in the process of designing and developing a teaching task or learning situation as a framework of different levels. This complexity is evident both in the process of development by the multi-grade teacher and in the approach and performance of the students in the multi-grade classroom when solving these teaching tasks.

These tasks contribute to the same teaching objective at each specific grade level, seeking to facilitate how multiple, relatively simple entities organize themselves. In this case, the different levels of development, assimilation, and depth come together to form a collective whole that creates patterns around the teaching objective. They utilize information and allow each student to evolve and learn in accordance with their potential, progressing to higher levels of development.

The authors of this article highlight that, in this particular aspect, another characteristic of complex systems finds its expression, as Díaz (2012) states: “The field of complexity is, in itself, a network of many different fields.” (p. 13)

Therefore, learning situations and teaching tasks demand different levels of depth, taking into account the potential of each type of learner, and from their approach, constitute a challenge to the intellect of each one, stimulating them to move to higher levels of development.

100% of those interviewed acknowledge that the design and development of learning situations with different levels of depth for students of the same grade with different levels of assimilation and development makes the planning, direction, control and evaluation of the teaching and learning process in the multi-grade classroom complex.

This is evident in the learning situation presented in the previous example. The students demonstrate their level of mastery of the content, which is pre-established in the school curriculum. By providing a correct answer to the learning situation, the teacher verifies that the students have mastered the content.

The interviewees agree that this learning situation does not pose a challenge to the intellect of students with average and high levels of assimilation, as it is a simple learning situation; the student only needs to find the successor to that number. By answering correctly, all students meet the minimum requirements established in the program or curriculum, but it does not facilitate the transition to a higher level of development.

100% of those interviewed suggested presenting learning situations at different levels of depth to challenge the intellect of students with medium and high assimilation levels in the same grade, and to facilitate their transition to a higher level of development. Table 2

Table 2: Example of learning situations with different levels of depth

For Assimilation Level Low	Medium Assimilation Level	High Assimilation Level
What is the successor to 99?	What is the successor of the largest two-digit natural number?	What is half the successor of the largest two-digit natural number?

Source: Prepared by the authors

According to the authors, the learning situation for students at an average assimilation level involves the same solution, but it presents a challenge to their intellect, as it is a three-part learning situation. To solve the exercise, the student must first answer two questions that underlie the text:

- First: what is a natural number?
- Second: What is the largest two-digit natural number?
- Third: find the successor of that number.

By answering correctly, it also meets the minimum requirements established in the program or curriculum, but stimulates the transition to higher levels of development.

The same applies to the learning situation for students with a high level of assimilation, which presents a greater level of depth, since the student must answer three underlying questions beforehand, in order to be able to give a final solution to the exercise.

One hundred percent of those interviewed agreed that, in a multi-grade classroom, the learning levels of students in different grades vary, and a teacher interested in stimulating each student's progress to higher levels of development faces a complex task. They recognized that instead of creating a single learning situation around a single topic, they must create at least three for each grade; and instead of directing and controlling students' work on a single teaching task, they must do so in each grade, with at least three tasks that contribute to the same learning objective.

On the other hand, according to the authors, in this school environment of mutual learning, the processes of interaction inside and outside the classroom also become a complex unit. In most cases, students in the same grade who have a low level of assimilation and are presented with a simple learning situation may show interest in other, more in-depth learning situations. For an inexperienced teacher, the interest of students for whom a particular learning situation was not designed may seem like interference, an obstruction, or a sign of indiscipline.

One hundred percent of those interviewed stated that students not only interact with the assigned task or learning situation, but also that interaction occurs among students with different levels of cognitive development within the same grade. Thus, a skilled teacher takes advantage of these opportunities and facilitates peer interaction through these tasks or learning situations with varying levels of depth.

They emphasize that in this type of learning scenario; more advanced students explain some of the teaching content to less advanced students, becoming teachers of others. This fosters a solid grasp of the content and encourages less advanced students to progress to higher levels of development. These analyses reaffirm Morin’s (2007) view, which considers complexity as a quantitative phenomenon, an extreme number of interactions and interferences among a very large number of units. (p. 59)

According to the authors of this article, the previous example demonstrates the complexity of planning, directing, controlling, and evaluating the teaching and learning process in single-grade classrooms. It can be inferred that in multi-grade classrooms, the teacher's performance becomes even more complex, as the complexity of planning, directing, controlling, and evaluating the teaching and learning process doubles, triples, quadruples, quintuples, or even sextuples depending on the number of grades in the classroom.

One hundred percent of those interviewed stated that in the area of Mother Tongue, teachers interested in providing adequate attention to diversity can present students with learning situations at different levels of depth (Table 3). This stimulates the transition to higher levels of development, which also makes the teacher's performance in the planning, direction, control, and evaluation of the class more complex.

Table 3: Example of Mother Tongue learning situations with different levels of depth for a grade:

Assimilation Level Low	Medium Assimilation Level	High Assimilation Level
Learning situation: Write three nouns that begin with the letter f	Learning situation: Write three common nouns that begin with the sixth letter of the alphabet and are made up of two syllables.	Learning situation: Write three common nouns that begin with the letter of the alphabet that precedes g, that are made up of two syllables and are stressed on the last syllable.
Possible answer: Felipe, family, edge	Possible answer: farm, happy, mud	Possible answer: fatal, ending, happy

Source: Prepared by the authors

One hundred percent of those interviewed confirmed that it is common for some teachers in multi-grade classrooms to focus their efforts on ensuring that all students in the group meet the pre-established curriculum objectives for each specific grade level. For these teachers, it is sufficient that the students meet the minimum requirements outlined in the curriculum for each subject area and grade level.

They point out that, regarding the management of the teaching and learning process in a multi-grade classroom, different educational contexts are permeated by a closed, single-purpose teaching approach that offers rote learning, promotes monolithic thinking, and fosters rigid mindsets. This type of teaching limits students' progression to higher levels of development, and academic growth may only be observed among students with a lower level of understanding.

In this regard, they point out that students with average and high levels of assimilation stagnate because they only know one path and perceive themselves as remaining in an uncomfortable phase for extended periods, allowing for very little progress. In addition, in multi-grade classrooms, they suggest that the teacher encourage each student to move toward higher levels of development. According to the authors, this also places the teacher in this type of classroom in a complex performance position.

However, for the multi-grade teacher who leads the single class taking into account the assumptions of complexity theory referred to at the beginning of this article, the teaching-learning process becomes a very complex unit.

According to De los Santos (2022):

Multigrade rural classrooms are characterized as a prime example of diversity within diversity. They bring together students of different ages, grades, interests, needs, and abilities, creating an environment conducive to the development of inclusive, diverse, and heterogeneous pedagogical practices. Despite this, it is common to see that multiple factors in these classrooms limit teachers in developing contextualized teaching adapted to the needs of the students (...) (p.1)

The authors corroborate that, in order to transmit knowledge and develop and train skills, habits, and values to students with different ages, different levels of cognitive development, and different levels of assimilation, in addition to the accumulation of difficulties that some students carry with them as they move from one grade to another, the teaching and learning process in the multi-grade school is a complex of complexities.

Given the many dimensions that coexist in the multi-grade school context, teachers unfamiliar with the principles of complexity theory often opt for a flat, homogeneous, or linear teaching process. Directing this process in a homogeneous or linear manner, without considering the different levels of assimilation of each

student in each grade, skews the individual growth of each student as a whole, with significant and lasting disadvantages for those with average and high levels of assimilation.

The latter are forced to learn what is pre-established in the curriculum and their learning progresses at the same pace as the others in the multi-grade group, limiting their development and progression to higher levels.

For this teacher, it is enough that the students meet the minimum requirements, and instead of making them grow and develop their skills and abilities, he places them, at most, at the level of the student with an average level of development, thus making the teaching-learning process a process of transition to higher levels of development for students with a low level of assimilation, of stagnation for those with an average level of assimilation, and of regression for those with a high level of assimilation.

Conclusions

If they are to be effective in their performance, teachers of multi-grade classrooms must take into account that the school is a complex organization, given that complexity theory is a field of study that shows the reality of education as an irreversible phenomenon over time, unstable, chaotic, of high complexity, considering the multiple dimensions that coexist in the multi-grade school context.

The multi-grade teacher who opts for a flat, homogeneous, or linear teaching process biases the individual growth of each student as an entity with notable and lasting harm to those with high levels of assimilation, who are forced to learn what is pre-established in the curriculum, keeping them at the same level as the other students in each specific grade.

In the multi-grade classroom it is possible to manage the potential of the students and the content to create a complex learning environment, where school tutoring, the collaboration of the strongest and most advanced with the weakest and least advanced play an important role in the dynamics of the class, which become a space of complex performance for the teacher.

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