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Complexity and the development of transdisciplinary competencies in Virtual Learning Environments of Higher Education Institutions in Mexico and Colombia

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Abstract

Complex thinking is a cognitive ability that allows people to solve problems using multiple approaches, forming flexible or creative thoughts and manipulating information; on the other hand, virtual learning environments allow students to learn in a variety of ways, so the symbiosis of both categories is important when addressing knowledge acquisition at the higher level. The study presents preliminary results of the project entitled "Higher education, complex thinking and transdisciplinarity. Design of a metacomplex virtual classroom model" through the application of an instrument designed and validated specifically for this research. The subjects of the study were students of the Virtual Education Department of the Universidad de Boyacá, Colombia, and students of Distance Education of the Universidad Mesoamericana, Mexico, in undergraduate and graduate courses of different disciplines. The sampling used was non-probabilistic with the simple random criterion, so that those selected were chosen because they were enrolled in a virtual course in semester 2022-1. A sample of 158 students who answered the questionnaire was obtained, and the fieldwork was carried out from April to May 2022 with the application of the instrument that was previously designed and validated. It is evident that most students are not familiar with the concept of complex thinking and its adjacent categories, however, there is a generalized belief of the benefits that the inclusion of these concepts and categories would have at the time of involving them in studies through virtual platforms. The research intention recognizes the postulates of different authors about complexity and how the concepts work and allow understanding of the needs to inhabit virtual classrooms and provoke moments of interaction, learning, interrelation and coexistence in the distance, from these theoretical-methodological indications it is expected to transform curricular the distance education programs of the universities studied.

Keywords: Complex thinking, interdisciplinary, complexity, virtual learning environments, metacomplex virtual classrooms.

Introduction

Edgar Morin is one of the world's most recognized thinkers on education today; he has written extensively on a variety of topics, but his work on complexity remains particularly relevant and influential. In particular, Morin's writings on education reflect his understanding that modern society faces unprecedented levels of complexity; as societies become increasingly complex, it becomes increasingly difficult for people to understand and navigate their environment. Consequently, education must adapt to this

changing landscape to ensure that students are equipped with the skills they need to participate effectively in contemporary life (Morin and Pakman, 1994; Grinberg, 2002; Morin, 1995).

To use complex thinking in teaching, it is important to understand the different types of thinking that are involved, which leads to thinking about the importance of involving the student in the learning process, as students often learn best when they actively participate in the process, need to feel that they are part of the process, and should be able to understand what they are being taught (Chaves, 2010; Collazos, 2007; Lozada, 2018).

Complex sciences have always been a challenge for traditional educational systems. In recent years, with the rapid development of information and communication technologies ICT, there has been an increased demand for online learning in these fields. Virtual learning is a possible solution to meet this need, as it allows students to receive instruction from various sources at any time and place they choose (Maldonado, 2017; Cervantes, 2018; Maldonado and Gómez, 2010).

Complexity, education and transdisciplinary

Complexity in its simplest sense is that which has the quality of being complex, i.e., it refers to something that is made up of different elements that interrelate and interact with each other. In this case, it can refer to systems whose components are interrelated but whose behavior and properties are not visible to the naked eye. Complex systems are therefore the result of a series of simple connections that become an intricate network that enables or facilitates their functioning. According to Morin (2011), the complex is that which is woven together. Although it may seem that the world is made up of separate units, the complex shows that what at one level appears to be monolithic unity is a web of relationships. Instead of difficult, complicated, or entangled, the complex presents itself as a web of relationships. The difficult, the complicated and the entangled frighten us. The complex invites us to understand and challenges us to investigate it.

This notion of complexity has permeated educational environments and has been installed to overcome traditional education tending to the disintegration of knowledge and the propensity for the apprehension of phenomena in a reductionist way. Therefore, it is expected that from the complex perspective pertinent teaching is offered from a planetary vision, which promotes the understanding and construction of the educational phenomenon as something more human, multidimensional, integrating, intercultural, transdisciplinary, recognizing error, uncertainty and diversity and a piece of knowledge suitable for addressing problems, for the formation of a citizen involved with the needs of their environment making an exercise of permanent transformation.

A complex task cannot be solved with the mere application of a series of steps or algorithms but requires a global understanding of the context in which it is circumscribed and the coordination of efforts for its resolution. However, situations involving human beings must be studied from a multidimensional perspective, allowing for the uncertainty inherent to complex systems, which opens the way to the adoption of new ways of approaching the study of phenomena, and this is how the Transdiscipline comes into play as a suitable scheme through which the appropriation of knowledge is promoted by attending to a complex perspective.

Transdisciplinarity transcends concepts such as interdisciplinary or multidisciplinary since it promotes knowledge between, across and beyond disciplinary areas, simultaneously at different levels of reality, to have a better understanding of the world (Almarza, 2006), quoted in Zamora-Araya, (2019, p. 74). The above is compatible with the notion of learning as a constructive process as proposed by Piaget and can be assimilated with the meaning of transdisciplinary whose objective has been to move from simplicity to complexity, that is, to take a considerable step toward the apprehension of the phenomena from the approach of all its dimensions.

It is necessary to erase the boundaries created by the reductionist contexts of the disciplines and, through more participatory and integrationist conceptions, to advance towards pluri-, inter- and transdisciplinary positions, since these complex

interrelationships are what have allowed important achievements in science. It is also fundamental to point out that the notions behind this disciplinary exchange must be kept in mind, such as cooperation, an adequate articulation of ideas, having a common object of study or a shared project (Morin, 2010, p.6).

Complex thinking and pedagogy

It has become a frequently mentioned topic in the educational field the reflection on complex thinking, understood as a human being's ability to know reality from multiple perspectives and dimensions, that is, to relate and integrate the elements that can explain the different objects of study. According to Morin (2011), in essence, a strategy that has a globalizing intention, which means that it tries to cover all the phenomena in which it is present, but taking into account both their particularities and the diverse events that they are. This concept is contrary to that of simplifying thinking, which unifies all knowledge in a single vision, annulling the possible diversity and leading the subjects to a "blind intelligence". Complex thinking entails a series of principles, among which are the following:

- The systemic or organizational principle, hologrammatic, retroactive loop, recursive loop, autonomy/dependence, self-organization, dialogic and reintroduction of the knower in all knowledge.

- The systemic or organizational principle: the systemic idea, which is opposed to the reductionist idea, is that the "Whole is more than the sum of its parts". The organization of a whole produce new qualities or properties concerning the parts considered in isolation: the emergences of the whole, the emergences of the parts and the emergence of the whole.

- The "hologrammatic" principle: highlights this apparent paradox of complex organizations in which not only the part is in the whole, but also the whole is inscribed in the part.

- The principle of the retroactive feedback loop: introduced by Norbert Wiener, allows knowledge of self-regulating processes. Breaks with the principle of linear causality: the cause acts on the effect and the effect on the cause.

- The principle of the recursive loop: overcomes the notion of regulation by that of self-production and self-organization. It is a generating loop in which products and effects are themselves producers and causes of what produces them.

- The principle of autonomy/dependence (self-eco-organization): living beings are self-organizing beings that, for this reason, expend energy in maintaining their autonomy. "The principle of self-eco-organization is specifically valid for humans, who develop their autonomy in dependence on their culture, and for societies, which develop in dependence on their geo-ecological environment" (Morin, 2002, p. 100).

- The dialogical principle: unites two principles or notions that should exclude each other but are inseparable in the same reality. The dialogical allows to rationally assume the inseparability of contradictory notions to conceive the same complex phenomenon.

- The principle of reintroduction of the knower in all knowledge. All knowledge is a reconstruction/translation made by a mind/brain in a given culture and time.

Considering the above, thinking complexly means incorporating a series of elements that allow subjects to make multidimensional comprehensions and integrate multiperspective, as a learning option that allows integrating the recognition of the different elements that make up the phenomena of study, their relationships, coincidences, differences, contexts of application among many other issues. It is a strategy that is incorporated and that facilitates the learner to build and reconstruct according to the events, alea, counter effects, and reactions that disturb the task at stake. Such a strategy assumes the aptitude to undertake a task in uncertainty and to introduce uncertainty in the behavior of the action, i.e., it needs competence and initiative (Delgado, 2018, p. 26).

From this perspective and understanding of the notion of complex thinking, it is necessary to think of emerging pedagogies that tend to promote dialectical processes with a greater degree of emphasis on dynamics and relationships than on structures, which implies in the first instance to conceive the student as a dynamic subject, with the capacity to inquire, who contributes from his own experiences and who is part of a context, that is, to recognize that in him, a historical-natural process converges and that he carries it, as a concrete minimum. A sense that changes the whole panorama of the educational process, since, from this point of view, it is related to the totality, of the training process.

If complex thinking permeates the pedagogical, radical changes must be perceived in the ways of approaching knowledge. It is expected that the autonomy of students in their tasks as learners be promoted, that the didactics through which learning is dynamized involve the active participation of all educational actors, that innovative models that promote the development of complex cognitive structures be incorporated, and that use be made of educational technologies that take young learners down new paths and allow them to venture into other learning environments.

Virtual education in complex sciences

Virtual education is a flexible training model that works asynchronously and promotes, above all, student autonomy in the management of their time and resources for learning. It is a process mediated by technologies and allows the student to make use of all the elements offered by the Internet to solve the problems involved in learning under construction. In the knowledge society, new models and theories emerge to address training processes, among which the implementation of programs in open access learning platforms is contemplated, as part of the new paradigms of education.

The virtualization of education, according to Tafur (2014) cited in (Villelas, 2018), contributes to the expansion of educational coverage, due to the growing adoption of ICTs to support teaching and learning processes in higher education institutions and meet professional training, updating and training needs. Therefore, it is pertinent to establish a relationship between virtual education and the sciences of complexity, which are the sciences of the knowledge society. This being so, it is necessary to prepare educational actors to face the challenges involved in working with information and communication technologies, in addition to knowing how to do it collaboratively, given that this is the new horizon that is drawn in higher education institutions.

Villelas (2018) states that education is the field where interdisciplinarity and transdisciplinarity have a place in the complex sciences. It is about learning from other disciplines, languages, methodologies and approaches, which is characterized by being approximative, tentative, open, and adaptive, as a living system, which requires having an open-minded structure to accommodate diverse possibilities. This includes technology, which becomes a privileged means to open the doors to emerging knowledge.

The teacher and the virtual world: a transcomplex perspective

Considering the above and the challenge that offering a renewed education implies at present, the task of one of the most important authors of the educational act comes into play: the teacher. They are the ones who have the main challenge of changing the ways of approaching education from a complex perspective, which involves learning new strategies and teaching styles and accepting different ways of doing it. Disciplines emerge and with this, innovative didactics must emerge that include virtuality and the use of ICT and TAC as suitable means through which different knowledge can be integrated and knowledge can be made more complex.

Based on the above, an imminent need arises, to change the merely instrumental concept of technologies and understand them as generators, creators of spaces that allow the creation of educational environments that stimulate and enhance participation, communication and interpretation from a transdisciplinary stance. It is unavoidable to escape from technological advances, since virtual environments are

increasingly becoming powerful information tools worldwide, and it has been shown that they transform the traditional levels of teaching as they require the teacher to act in highly developed interactive spaces, with a large amount of information at their disposal, learning communities, cyberspaces, internet, social networks among others, a range of potentialities that demand a different look, the exegesis for the construction of knowledge and new meanings that can transform the educational reality (García, 2021. p. 241).

In line with García (2021), from this angle of reality, the teacher in his actions must assume a leading role to intervene in the weaknesses that education is going through, university institutions try through various training offers to give an approach of deep interaction and interdependence with teaching and teaching where the teacher is a key player in the training process, as Balza (2005, cited in García, 2021) points out that "the dimension of knowledge allows conceiving the university teacher of the 21st century as a transdialogical and trans-systemic being in a permanent process of construction, formation and transformation, meaning that the teacher can never pretend to transform what is outside him if he is not able to transform himself, that is, to question his thoughts to transform himself" (p.246).

Virtual communities, youth and learning

Virtual communities are defined as "... social aggregations that emerge from the network when a sufficient number of people engage in public discussions for a sufficiently long time, with enough human sense to form networks of personal relationships in cyberspace" (Rheingold, 1993). There are different types of virtual communities, among which are social networks, blogs, gaming communities and many others that have been created and that have allowed exchanges where young people intervene more frequently. Generally, they approach them moved by curiosity, by concerns, by particular motivations or by pure necessity, finding a space for connection, exchange, recognition, and belonging, where it is possible to collaborate, design, produce and share, in short, and almost without realizing it, learn from others and with others. (Bosco et al., 2016, p. 27).

According to Montes de Oca et al. (2011, cited in Bosco et al., 2016, p. 27), these virtual communities incorporate many of the characteristics of discourse, practice or knowledge construction collectivities which makes it difficult to draw a dividing line between them, as well as to determine when a virtual community promotes practices that contribute to the learning of its members. Subjects also tend to use social networks to satisfy emotional needs or socialize or produce knowledge and learn. However, in almost all virtual communities, whatever their type, the idea of learning as a social construction is emphasized. In other words, knowledge, skills or attitudes derive mainly from the interaction between people. According to the authors, there are four types of communities based on the form of access:

- Open: the creation of a user profile (registration) to be able to consult or publish content is optional.
- Semi-open: registration is not required to access the contents, but it is necessary to be able to publish and interact with other users.
- By registration: registration is required to be able to consult and publish content and interact with other members.
- By invitation: the possibility of registration is defined by the administrators, moderators and/or community members.

In addition to being spaces for meeting and interaction among members around a common interest, communities are spaces for the production or exchange of content: photos, videos, news, and texts, among other aspects. Their purpose can be the elaboration of original content by members, individually or in groups, sharing content previously created by other individuals, institutions, or virtual communities or sharing and producing original content also produced by others.

Bosco et al. (2016) emphasize some aspects of this type of community; in the first instance the need to pay attention to the relationship that can be

generated between young people and the possible organizations that manage to sponsor the community, as well as the consequences for their learning and the construction of their identities. Secondly, the identification of shared purposes among members may promote very different types of exchange and learning. The authors assert that these communities based on common interests, referred to by them as "communities of interest", need to be explored much further. This research could show the ways forward to propose learning collectivities with which young people identify and in which they work based on their training interests, as shown in Table 1.

Table 1. Research that served as a basis for the approach of the constructs raised.

Authors	Dimension worked on
Arango-Forero, G. (2013). Comunicación digital: una propuesta de análisis desde el pensamiento complejo. Palabra clave, 16(3), 673-697.	Digital communication
Santos Rego, M. A. (2000). El pensamiento complejo y la pedagogía: bases para una teoría holística de la educación. Estudios pedagógicos (Valdivia), (26), 133-148.	Complex thinking and pedagogy
Picón, P. E. C., & Correa, L. J. H. (2021). Pensamiento complejo y educación: Una mirada desde el enfoque pedagógico de Lipman. RIEE| Revista Internacional de Estudios en Educación, 21(2), 109-117.	Complex thinking and education
Calvo Cereijo, M. D. C. (2019). Pensamiento complejo y transdisciplina. Sophia, colección de Filosofía de la Educación, (26), 307-326.	Complex thinking and transdiscipline
Zamora Viracacha, E. (2021). La metodología interdisciplinar en el proceso de inmersión a la educación virtual en la Institución Educativa Doce de Octubre.	Interdiscipline and educational innovation
Benítez, U., & Sandra, L. (2019). El pensamiento complejo y la innovación tecnológica y educativa en las universidades del futuro. Anuario del Sistema de Educación en Venezuela. 7(7), 90-100	Complex thinking and educational innovation
Prado, M. D. J. C. (2015). Congruencia del pensamiento complejo de Edgar Morín en la metodología de la educación a distancia. Revista Espiga, 14(30), 75-82.	Complex thinking and distance education

Note: Information taken from book and journal databases.

Methodology

The present research focuses on the responses of the surveyed students; it is based on the existing relationship between the construct of complex thinking and Virtual Learning Environments at the higher level, so it is requested, on the one hand, the level of knowledge that the surveyed actors consider they have regarding the construct of complex thinking, and, on the other hand, the relationship that the construct has when it is developed in Virtual Learning Environments.

The objectives of the research are the following:

- To describe students' perceptions of the construct of complex thinking.
- Analyze the importance of Virtual Learning Environments when addressing a construct such as complex thinking or complexity.
- Determine the relationship between complex thinking and learning obtained in Virtual Learning Environments.

The instrument used was a questionnaire focused on measuring the relationship between Virtual Learning Environments and complex thinking, which was subjected to the content validity of Hernandez (2011) and the reliability of Cronbach's Alpha during the month of December 2021.

This instrument was developed ad hoc to know the characteristics of a teaching-learning model for virtuality in IES and its interrelation with the concept of complex thinking, a topic little addressed so far. A review of the literature on a range of topics related to the object of the study was developed, such as complex thinking, complexity, Virtual Learning Environments, distance education, technology and complexity, as well as similar instruments; although there is a little academic contribution on scales and questionnaires.

To analyze the content validity, a first version of the instrument was designed with 95 items, the questionnaire was analyzed by a group of experts, which are described below in Table 2.

Table 2. Experts who validated the questionnaire [1]

Group of experts	Characteristics	Expert profiles
6 professionals	Methodology specialists with profiles in common with teachers or doctors in education, complex thinking and philosophy who have a wide and varied professional experience, have theoretical and practical knowledge in Virtual Learning Environments.	2 teachers of education 2 philosophy teachers 2 psychology teachers

Note: All the experts issued a critical analysis on the indicators of adequacy and relevance of the items (taking into consideration a scale of values from 1 to 4) indicating the level of agreement or disagreement using a Likert-type scale, about each of the categories being analyzed. 1) Totally agree, 2) Agree, 3) Disagree and 4) Totally disagree.

Once the scores of all the experts attributed to the sections of the instrument were obtained, these scores were transferred to the validity matrix to

[1]For the critical analysis of the instrument, the group of experts met in person for a 5-hour session, at the beginning of which each one was informed about the methodology proposed by Hernández (2011) that would be used to validate the instrument. The complete description of the validation of the instrument was published in the journal RaXimahi, of the Universidad Nacional Indigena de México, available at: www.unied.edu.mx

obtain the average and check the validity, obtaining a validity of .77, so it is considered to be an instrument with good validity. As a result of this procedure, 32 items were eliminated because there was no consensus on the part of the group of experts and modifications were made in the wording of some items to improve their clarity and comprehension, until the final version of the instrument was configured with 63 items.

To check the reliability of the instrument, we proceeded to calculate Cronbach's Alpha coefficient, a measure of internal consistency, which, as Welch and Comer (1998) point out, assumes that the items measure the same construct and that they are highly correlated; therefore, a pilot test was carried out with 5 stakeholders of a Higher Education Institution to obtain the reliability of Cronbach's Alpha coefficient, which yielded a value of α=.780, which shows high reliability.

The subjects of the study were students of the Virtual Education Department of the Universidad de Boyacá, Colombia and Distance Education students of the Universidad Mesoamericana, Mexico, at undergraduate and graduate levels in various disciplines. The sampling used was non-probabilistic with the simple random criterion, so that those selected were chosen because they were enrolled in a virtual course in semester 2022-1.

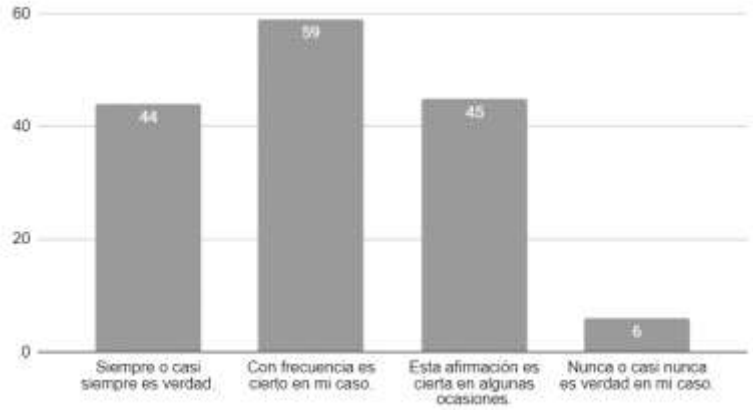
A sample of 158 students who responded to the questionnaire was obtained; the fieldwork was carried out from April to May 2022 with the application of the instrument previously described. The coordinators of undergraduate careers of the Universidad de Boyacá, Colombia and Universidad Mesoamericana, Mexico were asked for their support so that students assigned to their division would respond to the specific questionnaire that was designed. The results obtained were deposited in an Excel spreadsheet, which was used to design a frequency matrix and the various graphs presented below.

Results

To respond to the objectives of this research, a descriptive analysis of the items of the most representative dimensions of the instrument was carried out. The information obtained provides evidence of the importance that Virtual Learning Environments and complex thinking have acquired.

Figure 1.

Promoting the development of complex thinking should be a fundamental task of the teaching and learning process.



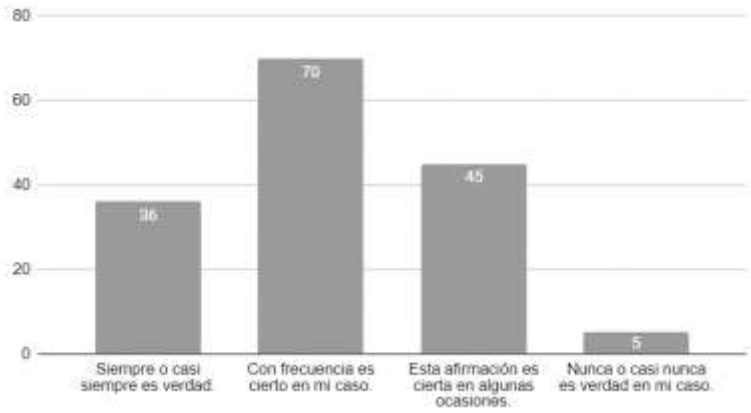
Note: More than 70% of students think that promoting the development of complex thinking should be a fundamental task in the E-A process

The teaching-learning process refers to the activities that teachers and students engage in to learn from each other. This process is a continuous exchange of knowledge between teachers and students through various modes of communication, such as face-to-face conversations, lectures, group work or discussions. Most educators believe that teaching is an interactive process in which the teacher tries to understand what his or her student knows and needs so that relevant information can be provided to them in a way that helps them improve their skills. In addition, effective teaching also helps develop critical thinking skills for students, which allows them not only to learn but also to grow intellectually.

In this sense, students should be able to think critically and understand complex topics (Menéndez and Zambrano, 2016; Sánches, 2003).

Figure 2.

To favor complex thinking, new knowledge is needed that identifies, projects and consolidates different mental structures elaborated through training and that promotes cognitive flexibility and openness to the multidiverse.



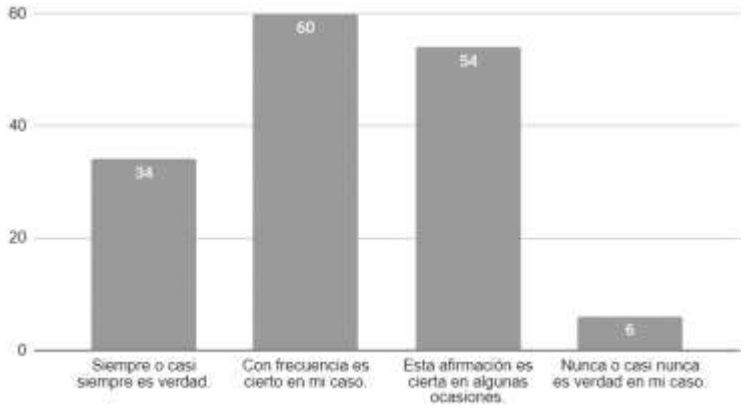
Note: The vast majority of students think that to favor complex thinking, new knowledge is needed that identifies, projects and consolidates different mental structures elaborated through training and that promotes cognitive flexibility and openness to the multidiverse.

Cognitive flexibility has been defined in different ways by various researchers. However, all definitions share the same essential characteristics: cognitive flexibility is the ability to switch between different ways of thinking or behaving, and is especially important when responding to novelty or change. This definition emphasizes that cognitive flexibility not only allows people to respond flexibly but also enables them to think outside the box. Openness refers to people's receptivity and willingness to explore new ideas and experiences. It can be viewed as an individual's attitude and behavior of openness to change toward new situations or environments.

Some studies have suggested that cognitive flexibility is also related to successful educational attainment, job performance, and general well-being. People who have high levels of cognitive flexibility are often better able to cope with change and adapt to new situations (Nó and Ortega, 1999; Pérez, 2019).

Figure 3.

From complexity, the ethical mission of teaching is adopted, seeking dialogue between ideas, favoring the encounter between human beings, and creating bonds of solidarity in pursuit of a humanized science and philosophy.



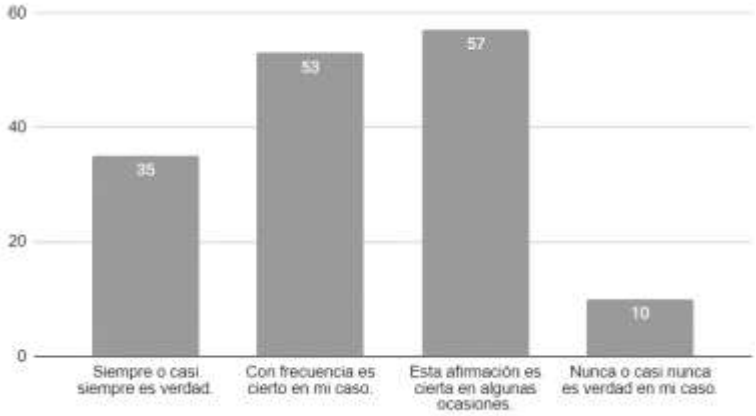
Note: Most of the students think that the ethical mission of teaching is adopted from the complexity, seeking dialogue between ideas, favoring the encounter between human beings, and creating bonds of solidarity in pursuit of a humanized science and philosophy.

Teaching should help students become responsible, compassionate, critical-thinking citizens who can make informed decisions in their lives. Consequently, students' convictions must be integrated into their approach to learning so that they can provide a coherent educational experience. Ultimately, complexity is key in teaching and learning. It makes topics more accessible and useful to students.

When teaching and learning, it is important to make topics as complex as possible. This makes topics more accessible and useful to students. It can also make topics more precise and nuanced.

Figure 4.

The dialogue of knowledge and complexity are inherent to the transdisciplinary attitude, which considers the world as a question and an aspiration.



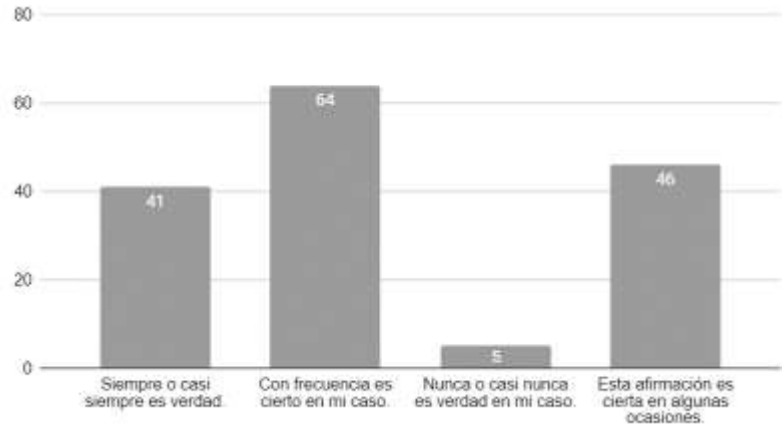
Note: Most of the students think that the dialogue of knowledge and complexity are inherent to the transdisciplinary attitude, which poses the world as a question and as an aspiration.

An interesting dialogue is taking place between knowledge and complexity, which has important implications for understanding the world around, as well as for the way to approach problems and make decisions. The two concepts constantly interact with each other, shaping each other in a never-ending process. As complex systems become increasingly aware of their functioning, they create new levels of order that may ultimately challenge existing knowledge about nature and human behavior.

Dialogues have the power to change perspectives. Even the simplest conversation can help to better understand another person and build relationships. It can also help to see the world from a different perspective and gain new insights. It can open the minds to new possibilities and introduce to different ways of thinking (Garcia, 2005; Calzadilla, 2004; Oliva 2007).

Figure 5.

Technologies of Learning and Knowledge define new roles for institutions, teachers and students, which open the way to think about the incorporation of transdisciplinary teaching that favors the dialogue of knowledge that favors the complex knowledge of the phenomena under study.

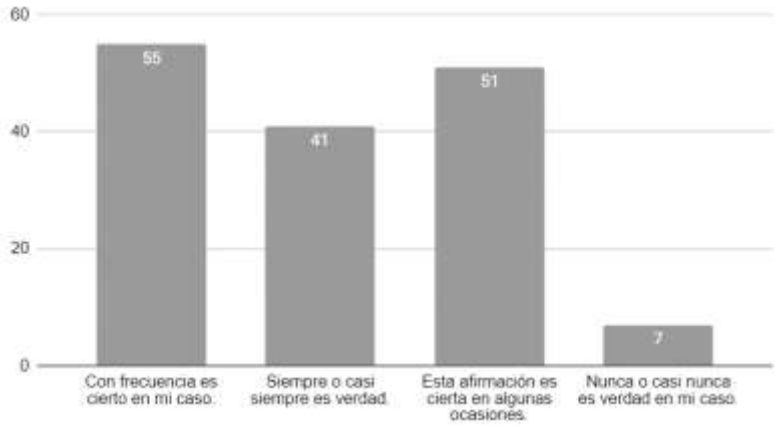


Note: Many of the students think that Technologies of Learning and Knowledge define new roles for institutions, teachers and students, which opens ground for thinking about the incorporation of a transdisciplinary teaching that favors the dialogue of knowledge that favors the complex knowledge of the phenomena under study.

Technologies for Learning and Knowledge (TLK), and specifically Virtual Learning Environments (VLE) have the potential to bridge disciplinary boundaries, stimulate innovative thinking in all fields, promote understanding of complex phenomena, and support collaborative research. VLE can be used in undergraduate courses in various disciplines with a focus on critical thinking skills. The TLK helps students break down traditional pedagogical boundaries, foster collaborative learning and build bridges between disciplines, gain a deeper understanding of the world around them, develop critical thinking skills, and better appreciate the contributions of different disciplines.

Figure 6.

It is necessary to understand very well what is transdisciplinary to propose the use of TLK as a mediator of such learning.



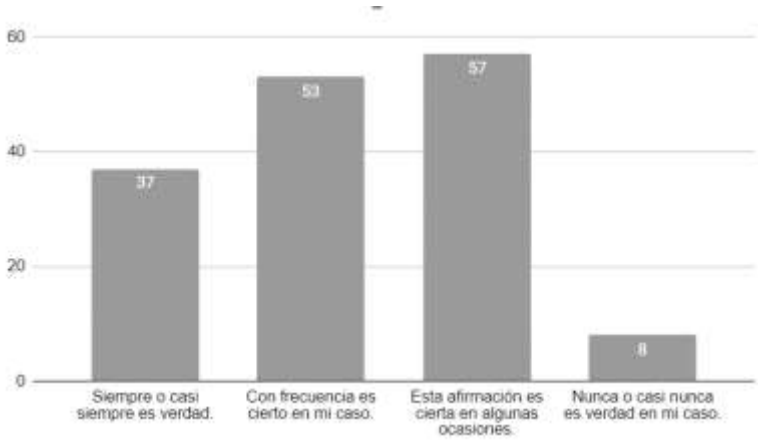
Note: Many of the students think that it is necessary to have a good understanding of transdisciplinarity to propose the use of TLK as a mediator of such learning.

Many students have come to believe that learning technologies can be used as mediators of learning, this is because technology can intervene and structure students' thinking in ways that facilitate a deep and meaningful understanding of concepts. Many studies have been conducted in an attempt to understand how different types of digital interventions affect student performance. In recent years, there has been a growing interest among educators in the use of mobile devices and other forms of interactive media as tools for instruction, assessment, and collaboration (Lozano, 2011).

In recent years, there has been a flourishing of new learning technologies, such as online courses, digital textbooks and virtual communities. These new technologies enable learners to obtain and retain information more effectively and efficiently. They offer more opportunities for collaboration and group work, provide flexible opportunities for continuing education, and offer a wide variety of learning formats and technologies.

Figure 7.

I believe that transversality exists in virtual environments and in the tools that are proposed there.



Note: Most students think that transversality exists in virtual environments and in the tools that are proposed there.

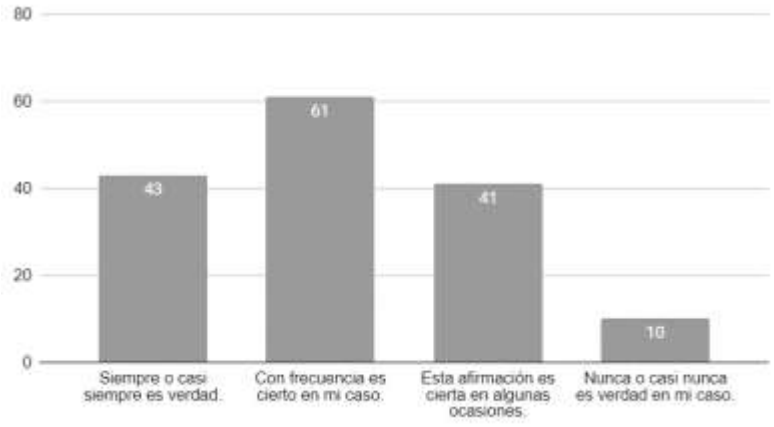
Transversality of learning is an educational concept that suggests that new knowledge and skills can be transferred across different contexts; according to this perspective, the context in which a learner encounters a situation or problem has an important impact on how he or she solves it. Consequently, learners should not only learn from a specific moment in time but also consider their experiences as they move through time and space. Virtual learning environments are designed to support this type of transfer by providing opportunities for learners to explore multiple perspectives on issues and challenge themselves with different problems. In addition, virtual learning environments offer teachers the ability to create customized lessons that reflect the unique needs of their students (Solé y Ríos, 2011).

With the increased use of technologies including the Internet and smartphones, more and more students are using virtual learning environments to supplement or replace face-to-face instruction. Cross-curricular is a concept that refers to how students can use a virtual learning environment to "walk in each other's shoes." Students can learn more effectively when they can use a virtual environment to explore and reflect on topics from different perspectives (Fernández, 2003; Retamal, 2010).

Crosscutting helps students connect the dots between different concepts and perspectives. When students can connect the different ideas and information in a virtual environment, they are more likely to understand what they are learning. In addition, crosscutting can help students learn strategies for problem-solving and critical thinking.

Figure 8.

As a student or teacher of virtual education, I consider that virtuality provides spaces to produce ideas and mediate as part of my learning construction.



Note: Most students think that virtuality provides spaces to produce ideas and mediate as part of my learning construction.

Virtual Learning Environments are created to provide a learning environment where the learner can be anywhere in the world, at any time and on any device. VLE is used in knowledge building in a variety of ways, to provide instructors with real-time feedback, to allow students to interact with teachers and classmates from anywhere in the world, and to support collaborative learning. They provide a level of immersion that can help students better understand complex topics and allow for flexibility and remote access to resources.

Discussion and conclusion

Complex thinking is a cognitive process that enables people to solve problems and understand situations in which they are involved; it involves the ability to think about multiple aspects of a problem, analyze them and find possible solutions. Complex thinking skills can be used for different purposes, such as academic achievement, professional success, creativity, critical thinking and decision making. The benefits of developing complex thinking skills include:

- better decision-making skills
- faster learning rates
- improved critical thinking skills
- better problem-solving skills
- better ability to think outside the box
- better ability to think creatively
- better general intelligence

Ways to develop complex thinking skills include:

- limit distractions while studying
- practice problem-solving methods
- practicing analytical thinking
- practicing conceptual thinking
- practicing critical thinking skills
- practicing thinking at different levels

By implementing these categories in Virtual Learning Environments it is possible to improve problem-solving skills, learn faster, think more critically and increase their general intelligence, as they offer a new way to study, access course material and other resources from anywhere, anytime, on their schedule, as well as providing opportunities for asynchronous or synchronous instruction, collaborative work, group discussions and more flexible student-teacher interaction than traditional classrooms. Several studies have shown that the use of EVA is an effective way to improve student outcomes by facilitating student learning without disruption or absence from class, as seen during the Covid-19 pandemic.

At the Universidad de Boyacá and Universidad Mesoamericana, respectively, physical classrooms are often combined with new technologies, such as whiteboards, laptops and interactive projectors, which allow professors to project videos or slides on the board and also allow students to interact with the material in real-time and thus have the possibility of self-correction.

Finally, this is the first research stage in the intention to create a model of metacomplex virtual classrooms, as a type of system that provides online courses designed to enhance and facilitate the teaching process for students, these metacomplex classrooms are learning environments consisting of several interconnected classrooms that collaborate in real-time. Unlike traditional virtual classrooms, which consist of large rooms where all students are present, metacomplex classrooms allow for the construction of multiple smaller interconnected classrooms, allowing groups of students to collaborate in real-time, share resources and provide feedback to each other. This higher level of interaction and collaboration allows for a more complete and comprehensive learning experience, enabling more effective and individualized instruction (Gonzalez, 2009; Pacheco, 2022).

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