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Fractal: an educational model for the convergence of formal and non-formal education

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Abstract

For the last two decades, different authors have mentioned the need to have new pedagogies that respond better to current times, which are surrounded by a complex set of issues such as mobility, interculturality, curricular flexibility, accreditation and academic coverage. Fractal is an educational model proposal for online learning that is formed by four basic elements that allow higher education institutions to advance in four different dimensions: teaching, knowledge, personal development and access. The elements that make up the model are: student-centered teaching, concept-based curriculum design, heutagogy, and openness. The present work describes the educational model and two possible applications of it in the area of Education, thus giving rise to an option that could transform the curriculum of a degree, while integrating in the formal environment of online education, the space for non-formal education.

Keywords: Concept-based curriculum; heutagogy; student-centered teaching; concept domain

Introduction

For the last two decades, different authors (Tünnerman, 2003; Adell & Castañeda, 2012; Bates 2015; Cobo, 2016) have mentioned the need to have new pedagogies that respond better to current times, which are surrounded by a complex set of situations that require reflection and to re- think about the way we educate students. In the specific case of universities, different drivers of change (both external and internal) are identified, which demand us to consider new perspectives in order to continue developing knowledge, understanding, research and outreach tasks that have traditionally been developed. Among the external factors, we find demographics, technological and labor aspects that have quickly changed the social and professional context, bringing up mobility, migration and permanent training into the scenario. Likewise, we also find internal factors related to the daily activities that occur within the universities. Since the end of the 20th century and at the beginning of the 21st century, several authors have pointed out the need to adapt universities' models to those that are more in line with the current context we live in, considering pedagogical methods centered on collective and self-directed work which allow, through curricular flexibility, personal learning paths with interdisciplinary approaches that combine formal and non formal education. These methods should also consider the strategic use of information and communication technologies, not only to provide materials, academic counseling and the development of learning networks beyond the formal classroom, but also to promote scientific and technological knowledge (González-Casanova, 2001; Tünnerman, 2003; Miklos & Arroyo, 2008; Redecker et al., 2011; Bates, 2011). In particular Schuetze, Bruneau and Grosjean (2012) mention:

> The old, isolated, ivory-tower university is outmoded as universities are driven in new directions. The trend toward networks of research and learning; internationalization with its unfinished agenda; the information and communication technologies with their potential, still largely untapped;

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> competitiveness and the attempt to create market niches; and commercialization have, or will have, effects that are difficult to capture by one single uniform model (Schuetze, Bruneau & Grosjean, 2012, p. 9).

At the same time, as there are opinions and specialists who talk about the transformation of universities, there are also experts in governance and university reform who have pointed out the difficulties that the traditional big universities are undergoing in order to renew and reinvent themselves since, in many cases, the internal processes that exist to modify organizational structures and curricula are long and complicated. Having said this, how could more flexible and open educational schemes be offered where formal and non-formal study converged? How can we reconcile the work carried out by teachers with the students' personal learning interests? What characteristics should educational models on which the new universities rely, have?

Elements of a flexible model of education

As it has been said in the introduction to this paper, the challenges facing universities are complex and it is believed that is difficult to address all of them in a single proposal. Even Enríquez (2017) points out how this concern has led to the birth of educational proposals, some of which arise within existing institutions that share a renewal interest while other proposals have been born completely as new institutions, under alliances with companies or non-governmental organizations, governmental organizations or, among institutions of education and research. Examples of these proposals are found in MOOC's (Massive Open Online Courses), Quest University of Canada (https://questu.ca), Alternative University in Romaine (http://universitateaalternativa.ro/), University of the People (http://www.uopeople.edu), Knowmads (http://www.knowmads.nl/), to name a few. All of these examples have a solid foundation in curriculum flexibility, which also include some other features such as the fusion of standardized contents with individualized content, learner-control with teacher-control, academic community with open communities; giving in this way, solutions that combine formal and non-formal alternatives to build knowledge (if we consider non-formal learning as Rogers describes it).

> Non-formal learning includes active, participatory, democratic, responsible, reflexive, critical and inter-cultural elements. Non-formal skills tend to be similar to everyday life skills, or at least, to be a means by which individuals can cope with their lives in different contexts. Non-formal competences could be specified in terms of acting as a bridge between formal knowledge on the one hand and informal aspirations, wishes and perceptions on the other (Rogers, in Singh, 2015, p. 38).

The educational model presented below is composed of four elements that are considered, to give rise to advance in four specific dimensions: curricular flexibility, adaptability to the environment, pertinence and academic belonging and, ease of access. The central elements of the model to achieve these objectives are student-centered teaching, concept-based curriculum design, heutagogy and openness (see Figure 1).

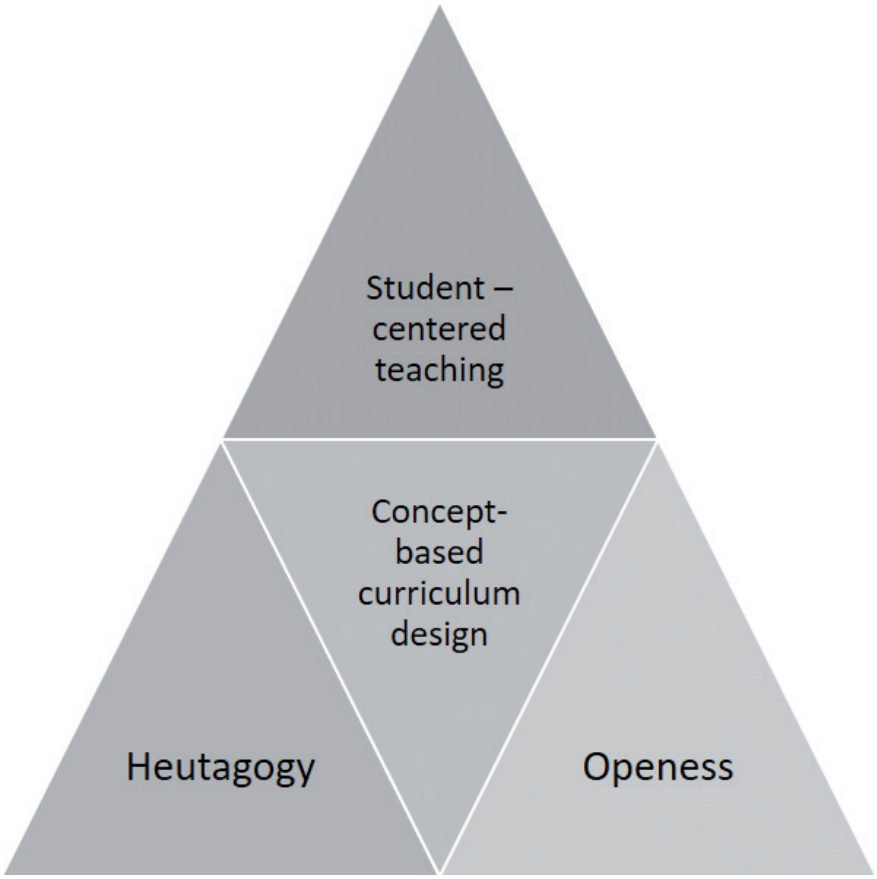

Figure 1: Components of a flexible model of education

The reason and specific focus of each of these elements is briefly described below.

Concept-based curriculum design

It is common to find, in the traditional models of education, that the content of the academic programs is composed by subjects or units that has generated, among other things, extensive detailed programs that, in the vast majority of cases, isolate a topic from the others. However, if we consider the essential concepts of a curriculum, we can optimize teaching and learning by concentrating on deep understanding of each term which, depending on the context to which it is translated, takes on new meanings (if we consider concepts to be cognitive units of meaning, which arise from the interaction with the environment and the previous knowledge we have, in the moment we relate this concepts with new ones, we can create new knowledge and even new concepts).

According to Erickson's work, concept-based curriculum design not only reduces curricular load in a course, but also helps to focus teaching on general and relevant aspects while making learning methods and strategies used by students more flexible (Erickson, 2008).

Erickson herself points out that concept-based design, when it is connected with prior knowledge, brings relevance and meaning to students' learning while causing students to process facts and skills

on deeper intellectual levels, as they relate to facts, strategies and skills linked to key concepts, their generalizations and principles. It also increases the motivation for learning by involving personal knowledge and, increases the fluency of language when students explain and defend their own understanding with reliable information (Erickson, 2008, p. 83).

In this sense it is considered that the curriculum based model gives the chance to easily introduce new concepts into the classroom, that emerge from the specific interests of the group.

Student-centered teaching

For the design of the new educational models, it is usually accepted that the role of the teacher changes from the transmission of knowledge to being a guide and a counselor in the construction of knowledge. As Benson points out, under this pedagogy, teaching focuses on identifying and adapting the different processes that are carried out in the classroom as well as the content, around individual needs, preferences and goals of students and is progressively involved in the negotiation and decision-making processes that affect their learning (Benson, in Burns & Richards, 2012).

As expected, a student-centered model of teaching is intended to address the diversity of students, promote academic accountability and active student participation, and foster the development of self-directed learning skills. Some strategies that, through time, authors such as Rogers (1969), Diaz-Barriga (2005) and Cobo (2016) have suggested to construct student-centered teaching environments, are: solving real problems, providing learning resources, creating academic contracts, designing research projects.

"The goal of learner centered teaching is to create learning environments that optimize students' opportunities to pay attention and actively engage in authentic, meaningful and useful learning" (Doyle, 2011, p. 9). Teachers then, have a big challenge generating and suggesting those personalized learning situations that enhanced knowledge building and skills.

Heutagogy

It is a term introduced by Kenyon and Hase (2001) to refer to self-determined learning in which, in addition to having skills related to self-directed learning, are also identified abilities linked to the social and professional adaptability of people. Blaschke (2012), mentions that heutagogical approaches have acquired enormous value given the emerging technologies we have, which consider student-centered teaching models as they promote student content development, self-direction, and self-definition of learning paths. Blaschke points out that heutagogy promotes the development of competencies and capabilities, understanding the difference between the two, as follows:

> Competency can be understood as a proven ability in acquiring knowledge and skills, while capability is characterized by learner confidence in his or her competency and, as a result, the ability to take appropriate and effective action to formulate and solve problems in both familiar and unfamiliar and changing settings (Blaschke, 2012, p. 59).

Some of the traits that the author remarks that capable people possess are self-efficacy, communication skills and teamwork creativity to apply competencies in new and unfamiliar situations.

Cobo (2016), in his book "*La innovación pendiente*" (in English, "Pending Innovation"), mentions that heutagogy attaches particular importance to ways of self directed learning, passing from a predetermined the domain of knowledge, to the possibility of creating self forms of dialogue with different knowledge. In this sense, heutagogy has to do with the development of metacognitive skills in order "to be capable of learning by creating, reconfiguring, unlearning and relearning, connecting the old and the new, as well as the curricular with the extracurricular" (Cobo, 2016, p. 45).

The idea of integrating heutagogical approaches with learner centered teaching is to emphasize the different roles that students and teacher play in the model. While teachers are expected to be aware of the personal and group interests of their students to integrate them into the curriculum in order to guide and motivate better their students, these last are also working on being responsible and aware of their own learning process, their capabilities, challenges and strengths.

Openness

The term 'openness' in education has been present for many years, considered to provide flexibility, whether for admission to an institution, attendance to classes, completion of studies and even for the permanence in an academic program of studies. Some of the characteristics that Enríquez lists to distinguish open education are the following:

- It arises with the intention of offering alternatives of access to education to important sectors of society.
- It removes or relaxes organizational, geographical, temporal and even academic restrictions.
- It strongly relies on materials and study guides.
- It requires and promotes attitudes related to self-learning, self-responsibility and relative independence of the learner.
- Advisers or counselors may exist to resolve doubts.
- Learning occurs in isolation.
- Used in formal and non-formal education programs.
- It is more strongly supported in mass media (Enríquez, 2015, p. 2).

For the specific case of this model, the concept of openness focuses on the flexibility of access. Building open learning spaces, not only for students enrolled in the educational institution, but also to extend knowledge to other groups interested in the subjects, either to learn or to teach and share learning experiences and knowledge; digital technologies in this sense, play an important role.

As we have seen, although the four elements just described have been defined in different contexts, they all share common characteristics that appeal to curricular flexibility, the development of responsible, active and committed students (not only with their learning but with the very processes of learning something) and working with information and communication technologies. Under this scenario, it seems feasible to gather the four elements into one educational model that would combine formal and non-formal education through blended learning or completely online learning solutions.

Fractal, an educational model for the convergence of formal and non-formal education

In 2004, George Siemens introduced the connectivism learning theory to respond to the current context of study and work, where trends show an increasingly close relationship between both activities, because of the fast changing life cycle of knowledge, the need to learn continuously and constantly, the greater number of training options through informal education and, the transformation of thought by the presence of technologies and computer networks. In this theory, Siemens mentions that

> learning is a process that occurs within nebulous environments of changing basic elements - not entirely under the control of the individual. Learning (defined as actionable knowledge) can reside outside ourselves (within an organization or database), focuses on connecting sets of specialized information, and the connections that enable us to learn more are more important than our current state of knowledge (Siemens, 2004).

The process mentioned by Siemens, occurs every day when facing the study of a topic, either as part of an educational program or by personal initiative. We constantly seek information, examples and counter-examples of assumed positions, knowledge application environments, and third-party experiences, among others. The resources consulted are of different nature, which come from different spheres (academic, institutional, corporate, personal) and it is up to us to identify and select those that offer value and meaning for the interest we pursue. Having said that, there remains the concern to establish the way in which the learning process described by connectivism can be considered in educational institutions so that, on the one hand, it helps teachers and students to be aware of the role they play in the process just mentioned but, at the same time it also helps educational institutions to recognize the changing environment in which teaching and learning takes place and to consider it in its organization, policies and programs in order to acknowledge the learning that is acquired through different experiences and scenarios.

The Fractal concept

In the area of mathematics, fractal geometry refers to the specific geometry that arises from the theory of Chaos. Fractals are semi-geometric figures that have an essential structure, which is iterated at different scales, an infinite number of times. In other words, as Pappas describes a fractal is:

> …a form which begins with an object -such as a segment, a point, a triangle- that is a constantly being altered by reapplying a rule ad infinitum. The rule can be described by a mathematical formula or by words. (Pappas, 1994, p. 49)

Figures 2 and 3 show two well-known examples of fractals called the Koch curve and the Sierpinski triangle. In the case of the first example, the rule that we will apply consists on drawing a triangle on each of the lines of the initial figure; the basis of the triangle occupies the third part of each line. As we can see the initial figure is a triangle whose basis occupies the third part of a straight horizontal line. After the first iteration, we obtain two triangles and a star shape. After the second iteration, each of the “old” triangles becomes a star shape figure and, each straight line has a new triangle on it.

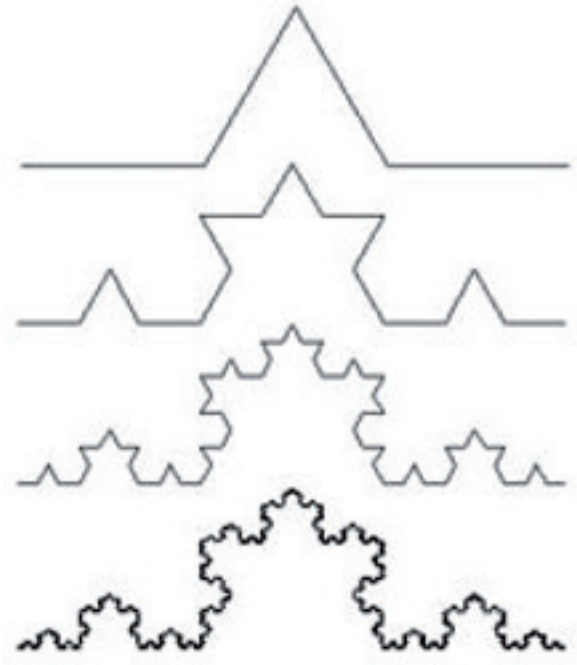

Figure 2: Koch's curve (source: Epsilones, 2017)

On the other hand, the Sierpinski triangle is obtained by applying the rule of joining the midpoints of each side of an equilateral triangle. The initial figure is an equilateral triangle. After the first iteration, we obtain three new equilateral triangles inside the original one. After the second iteration, we obtain nine new equilateral triangles. With the third iteration, we get twenty-seven new triangles, and so on.

Figure 3: Sierpinski's triangle (source: Microsiervos, 2015)

To describe Fractal, the educational model presented in this paper, an initial figure integrated by the four elements already mentioned is considered (concept-based curriculum design, student-centered teaching, heutagogy and openness). The iteration mechanism is determined by the continuous application of the educational model to the central element of itself: the concept-based curriculum design. This is because it is suggested that the study of each of the concepts that make up the curriculum of the course, when studied under the same educational model, give rise to the iteration of the initial figure. Moreover, if we allow the initial concept domain (the concept map that defines the relation between the initial concepts of the course) to be adapted by the working context and the specific interests of the students participating in that course, we obtain an indefinite number of iterations of the model. In this way, the Fractal model is represented as shown in Figure 4.

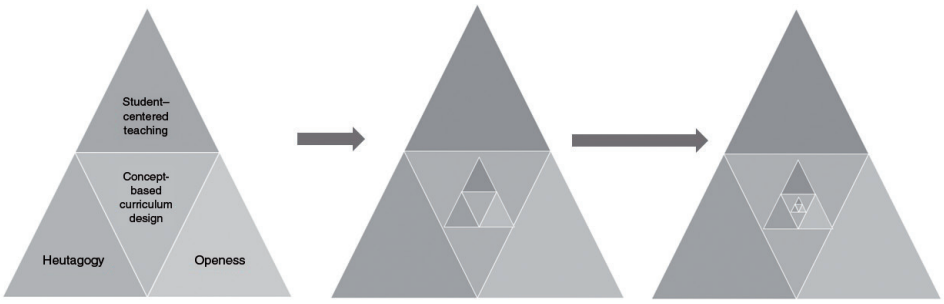

Figure 4: Fractal model

Fractal in detail

As mentioned before, the core element of Fractal is the concept-based curriculum design. The concrete way in which this model works is the following: we will name concept domain to the concept map that gives origin to a specific educational program; this map shows the fundamental concepts of the course in question.

The concept domain is the element that gives rise to the multidimensional study of a concept and to the analysis of its interrelation with other concepts, some of them proposed and integrated from the specific interests of each student and some other suggested by the teacher as he/she identifies concerns and learning opportunities. It is in this moment when the learner centered teaching and the heutagogical elements take place and, as a result of it, a personalized concept domain emerges.

Figure 5 shows an example of a concept domain that represents the starting point of a course that is the initial curriculum suggested by the teacher, and a second concept domain that emerges from the first one but it integrates those concepts that are of particular interest to a student. This second concept map would be a personalized concept domain that, among other things, also helps to establish a learning contract between the teacher and the student.

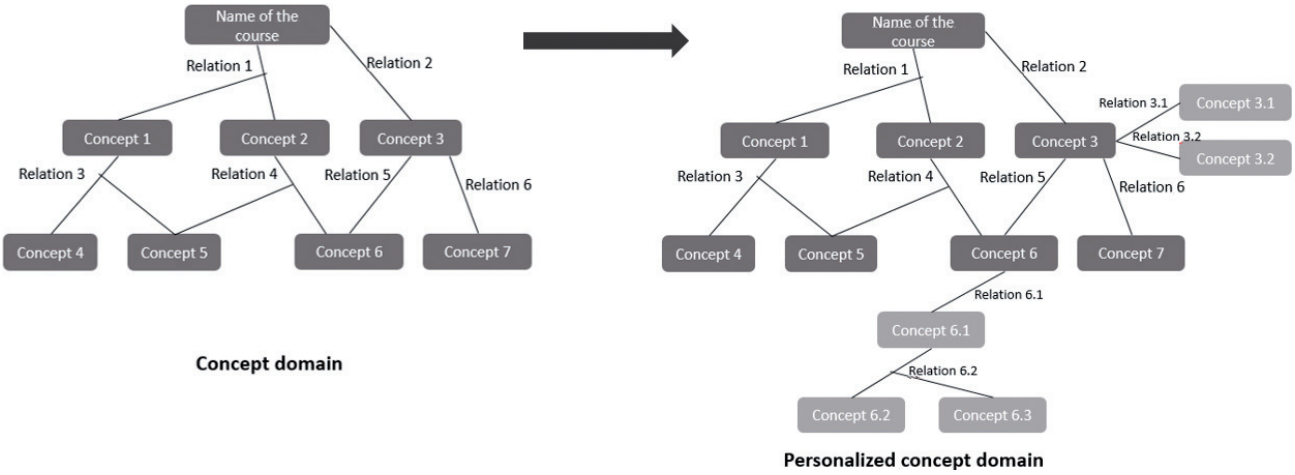

Figure 5: Concept domain and 1st. iteration

Just as the curriculum design is open and experiences modifications, the learning spaces are also open. New learning groups may be introduced and connected with this learning group, new teachers and experts might be invited to talk about specific approaches of a concept; new learning resources are expected to be suggested and used by both, teachers and students.

In this way, the depth, extension, and complexity of the personalized concept domain is determined by the student as a result of a self-determined study exercise that can be extended in time and place of study but which can also be repeated iteratively for each one of the concepts that form part of the concept domain in its different iterations thus, generating the property of self-similarity that we find in the geometric design of fractals.

Fractal, the educational model, resumes the principles of connectivism, in which the consolidation and maintenance of learning networks foster interdisciplinarity and continuous education, in a chaotic and rhizomatic model, to propose a concept-based curriculum design as the basis or starting point of the learning process.

Possible Fractal applications

Considering the elements of openness and heutagogy that conform Fractal, the following application examples are constructed in flexible environments in relation to the entry requirements and the curriculum of the course in such a way that benefit both, students enrolled in an academic program of the institution, as well as professionals looking for an update on a specific topic. In both cases there is room to attend a particular interest or approach, of the subject in question.

Example 1. Area of academic specialty

It is common to find in the curriculum of a career or degree, subjects that separate the theoretical part from the concept or, which isolate and separate the different perspectives that converge on the same phenomenon. For example, the degree in Pedagogy offered by the National Autonomous University of Mexico (UNAM), through the Faculty of Philosophy and Letters, has a curriculum organized by three curricular elements: subjects, areas and levels. The subjects are curricular units that have contents of theoretical, conceptual elements; of some moment of the historical process of education and pedagogy, of some aspect of the process of construction of pedagogical knowledge and of aspects of the pedagogue's practice. The curricular areas are a set of subjects that account for a global process or a dimension of the problematic field and the levels refer to the set of horizontally organized subjects, integrating different levels of complexity in the development of content processing (basic, Intermediate and specialization (CUAED-UNAM, 2017).

In particular, the area of Didactic Intervention, at the level of specialization, is made up of optional subjects where the student is faced with a more complete application, either of educational planning and school management; the didactic intervention; popular education or curriculum development. A Fractal application would be to group in a proposal, the work of four theoretical-practical workshops, of the curricular area mentioned (namely Workshop of didactics 1, 4, 5 and 6), linked to the design of a didactic intervention, under a didactic approach that the teacher chooses at the time. In this way, the new course would support teachers of all educational levels, students and researchers of education, to conceive didactic interventions from the approach that is determined. Under this broad panorama of participants, it is natural to expect that the course will present different perspectives, needs and concerns, according to the different interests and personal situations of each of the members of the group which would promote the definition of personalized concept domains that arise from the initial

concept domain proposed by the teacher and the dimensions of particular interest that students have (historical epistemological, social, labor, to mention some). The fundamental concepts of the concept domain could be: teaching strategies, learning strategies, didactic materials, learning environments; in addition to those specific to the determined approach being addressed.

Example 2. Multidisciplinary specialty

Another common situation that is recurrently faced by a student and a professional is that which refers to teamwork with people who come from other areas of specialization other than the area of personal study. This implies understanding another way of working and conciliating, in the study of a specific phenomenon, the different problems that derive from each of the perspectives of the disciplines involved. A concrete example that can be mentioned is in relation to the study of a topic that has arisen in recent years in the area of systems and education: Learning Analytics. According to the Society for Learning Analytical Research, it can be defined as "measuring, collecting, analyzing and reporting contexts, in order to understand and optimize learning and the environments in which it occurs" (SOLAR, in Durall & Gros, 2014). Thus, when working on data analysis to understand and improve learning processes, it requires the intervention of systems researchers, mathematical modeling, learning evaluators, and instructional designers. As in the previous example, from the specific interests and contexts of each one of the group members, personalized concept domains arise from an initial concept domain developed by the teachers. Some of the dimensions that may arise are epistemological, applicative, technological and educational, to name a few. The fundamental concepts of the concept domain could be: data mining, mathematical modeling, teaching strategies, instructional design, and platforms for learning.

Conclusions

Fractal is a proposal that takes the principles of fractal geometry where, from an initial figure, to which an iteration rule is applied, an infinite self-similar figure is obtained. In this educational model, the basic figure is defined by four basic elements found in successful educational experiences in the world as in prospective education exercises. These proposals focus their educational models on curriculum flexibility and learner autonomy to achieve better student participation and commitment, while at the same time, seek to better serve the personal and professional needs of each student. Both components are found in Fractal through the concept-based curriculum and heutagogical approach proposed by the model, which together with the learner-centered teaching and guidance and the possibility of interacting with different groups and communities, give meaning to the constant re-definition of the conceptual domain with which a course begins. In this way, it is possible to move from the domain of predetermined knowledge to the possibility of creating personal forms of dialogue with different knowledge, from several disciplines, as Cobo (2016) mentions or, in other words, giving rise to a comprehensive and interdisciplinary study perspective in which online work and the use of information technologies play a fundamental role to connect with different resources, data and study groups. Moreover, in considering the potential that the technologies offer to connect the students with groups external to the educational institutions, we also do it the other way around; that is, external groups are also joining the academic work of the university. In this way, the options of university extension are expanded and formal education with the non-formal, are intertwined.

In this way, Fractal tries to open up new opportunities for educational institutions to explore alternatives to jointly carry out, more significant academic and continued educational programs for students, where formal and non-formal education take place at the same time. Under this model,

through concept-based and flexible curriculum design, the universities offer a divergent view of study that also gives value to interdisciplinary and transdisciplinary participation that occurs beyond the classroom.

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