

## Review

# Key components of learning ecologies: A Delphi assessment

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## Abstract

The educational landscape has changed in recent years, requiring reflection about new pedagogical methods and theories. There are three important perspectives as drivers of pedagogical reflection: lifelong and life-wide learning, the idea of learning as a social construct in which internal elements and changing external factors converge, and the recognition of technology as a resource that can promote ubiquitous and expanded learning. Learning ecology has been proposed as a conceptual and empirical framework, but its still emergent nature along with its multidimensionality and complexity require further exploration. The Delphi study we present as part of a broader research project aims to identify the components of learning ecologies. Three panel rounds with international experts were carried out, after which two important dimensions emerged in the structure of learning ecologies. The first is related to intrinsic “learning dispositions,” which is made up of three categories: the subject’s ideas about learning, their motivations and expectations. The second dimension, called “learning processes,” comprises four components: relationships, resources, actions and context. The identification of the components of learning ecologies and their influence on formal, non-formal and informal training processes will provide guidance for educational policies and help to better organize training programmes.

# Practitioner Notes

What is already known about this topic

- The digital age has led to important transformations affecting what, how, when and where we learn.
- Learning continues lifelong and life-wide as a social construct where ever-changing contextual elements converge.
- Learning ecologies function as an integrative concept of the different kinds of learning in the digital age.

What this paper adds

- The identification of key components that make up learning ecologies.
- A model derived from the results of a Delphi study that shows the relationships between elements that form the learning ecologies.
- It underpins and improves the idea of ecologies as a reference for analysing learning in the digital era.

Implications for practice and/or policy

- The identification of the components of learning ecologies will help guide educational policies and improve the organization of teacher training programmes.
- Being aware of those components makes it easier for each person to be able to take advantage of learning opportunities in formal, non-formal and informal settings and has implications for self-directed learning.

## Introduction

The subject of learning ecologies has attracted the attention of several authors who have made considerable efforts to offer reflections and proposals based on both theoretical and empirical studies. Despite their dedication and the availability of significant studies, learning ecologies is still considered an emerging line of research which is in an embryonic state due to its complex, multidimensional and polyhedral character both at a conceptual and operational level.

Analogous to a natural ecological system, human learning inhabits a social space and comprises an intricate network of interdependencies that determines, characterizes, develops and transforms it to a greater or lesser degree. Human development is inseparable from the context in which it occurs. This principle constitutes an essential core of classic theories such as

those referring to ecological development from Bronfenbrenner (1979, 1994), historical-cultural theory from Vygotsky (1978) and the theory of activity from Leontiev (1978, 1981) and Engeström (1987). That represented a critical advance in the conception of human development influenced by contextual factors. However, the current fluidity of contextual borders, dissolving the boundaries between different environments (Area, 2012; Bauman, 2000) and their high permeability to external influences gives rise to the emergence of new contextual relationships and, hypothetically, to new instances of learning, that bio-ecological theory does not explain, despite some attempts such as Eaton (2014) and Gordon (2014).

A new ecological perspective has come into play under the name of information ecologies, in line with the perspective of the theory of activity (Kaptelinin & Nardi, 2006; Nardi, 1996, Nardi & O'Day, 1999). It focuses on how technology has become an indispensable mediator in specific contexts of human activity, creating new spaces that transcend geographical and spatial borders. Brown (2000) highlights that technology plays a vital role in the framework of learning ecologies. He considers them to be organized autonomously in virtual community settings, with specific areas of interest (Lave & Wenger, 1991) that persist over time. Within those areas the individual must have particular characteristics, which Lévi-Strauss (1964) called bricoleur, to be able to produce acts of communication, creation, development and dissemination (pollination) of knowledge that in turn produce changes in their context and contextual dynamics.

Barron (2006a, 2006b) goes a step further by proposing a systemic, integrating concept of ecology, in which not only are the peculiarities of informal spaces taken into consideration but so are the whole set of relationships, interdependencies and mutual influences between these and the formal and non-formal contexts. One of the specific values of Barron's ecological theory is the possibility of explaining the unity of learning in a multiplicity of settings. For Barron (2006a), ecology and learning are mutually determined, positively pointing out the subjects, objects and contextual circumstances of learning processes. Also, regardless of the space in which they occur, the learning activities generated by the student's personal interest and initiative, in addition to serving to provide knowledge, are the key to entering other contexts (boundary crossing) and consequently they play a significant role in the development of student identity. From Barron's perspective, learning ecologies are: "the set of contexts found in physical or virtual spaces that provide opportunities for learning. Each context comprises a unique configuration of activities, material resources, relationships, and the interactions that emerge from them" (Barron, 2006a, p. 195).

Jackson (2013) states that learning ecologies include the processes and variety of contexts and interactions that give the individual the opportunities and resources for learning, development and achievement over time that allows

the subject to learn from key elements such as the heterogeneity of contexts, spaces, relationships, resources, developed processes and affordances (Jackson, 2016).

Thus, from a pragmatic point of view, conceptualizing learning ecologies allows us to have a framework of referential analysis to understand how we learn, and what contexts and elements we use for our education, which entails access to new opportunities for learning (Luckin, 2008; Sangrà, González-Sanmamed, & Guitert, 2013). Being aware of the aspects or components that make up our ecologies is essential for learning to learn throughout life (Rocosa, Sangrà, & Cabrera, 2018), both personally and professionally, in formal and informal settings (Maina & García, 2016), where parameters such as space and time are no longer limiting due to the possibilities offered by technology.

Similarly, authors such as Sangrà, Guitert, Pérez-Mateo, and Ernest (2011) show that learning ecologies provide a common scenario for interpreting the multiple learning opportunities offered by the current complex digital landscape, in which the boundaries between the formal and informal are increasingly blurred and combined, giving rise to new ways of learning. It means, in the words of González-Sanmamed, Sangrà, Souto-Seijo, and Estévez (2018), an authentic metamorphosis of learning processes due in part to the empowerment of the individual to choose what, how, when and where to learn.

The learning ecologies approach is used to examine how various groups learn: doctoral students (Esposito, Sangrà, & Maina, 2015), teachers (González-Sanmamed, Santos, & Muñoz-Carril, 2016; Hernández-Sellés, González-Sanmamed, & Muñoz-Carril, 2015; Van den Beemt & Diepstraten, 2016), homeless people (Strohmayr, Comber, & Balaam, 2015) and Canadian entrepreneurial mothers (Christen, Sangrà, & González-Sanmamed, 2016).

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These ideas, reflections and representations come under the broad umbrella of learning ecologies and form part of the substrate from which various theories are configured, such as connectivism (Downes, 2012; Siemens, 2005, 2008, 2009).

Similar analyses to connectivism, such as emergent learning (Williams, Karousou, & Mackness, 2011), refer to the radical transformation of modes of production, interaction, communication and diffusion, commonly referred to as Web 2.0, which allow exchange and collaboration through social networks.

Rhizomatic learning (Cormier, 2008) would also be an excellent example of theoretical analysis drawing from the philosophy of distributed learning which is consistent with the perspective of learning ecologies and involves a co-

construction of knowledge from negotiation with participants in the learning process.

From this theoretical background, this current work aims to answer the following research questions: (1) How are learning ecologies perceived? and (2) What are the key components of learning ecologies? In this way, we aim to discern implications for the learner and training institutions to assess, expand and certify learning opportunities today.

The characteristics of the subject of study, its manifest complexity and the multiplicity of aspects to be considered in an analysis suggest the use of the Delphi technique. Following this technique, an in-depth investigation will be carried out to examine the different views of the experts consulted following a systematic process of guided reflection under rigorous monitoring and feedback parameters.

## **Methodology**

The Delphi method is defined as “a panel communication technique by which researchers collect expert opinions, enable experts to communicate anonymously with one another and then explore the underlying information collected” (Yeh, Hsu, Wu, Hwung, & Lin, 2014). The knowledge generated is reworked by the researcher and submitted again for the consideration of the panel until, after a certain number of iterations or rounds, they reach a situation that satisfies the research objectives (Adler & Ziglio, 1996; Cyphert & Gant, 1971; Keeney, Hasson, & Mckenna, 2011; Linstone & Turoff, 1975; Okoli & Pawlowski, 2004).

The Delphi method is often used to articulate the significant factors in complex entities, to explore still poorly defined situations, or to make decisions and recommend actions on problematic issues (Skulmoski, Hartman, & Krahn, 2007). Our study is of the first type insofar as the concept of ecology refers to a complex system (Cilliers, 2005; Williams, Karousou, & Mackness, 2011) characterized by the presence of multiple elements and relationships, organized in different levels and dynamics of operation (Kek & Huijser, 2017). This multidimensionality turns the task of studying learning ecologies into a problematic, challenging subject which benefits from the contribution of the different perspectives and judgements of the experts in the field (Donohoe, Stellefson & Tennant, 2012). Shaikh and Khoja (2014) also refer to the same exploratory function of the method when they state that the search for and identification of critical elements in environments that are still not well defined is one of the common approaches of Delphi studies.

### **AQ3**

The Delphi method has been used in many studies on education. Recently, it has been used in subjects related to the field of educational technology and higher education (López-Gómez, 2018). One can cite, eg, the study on the

main research topics related to Technology-Enhanced Learning (Plesch, Kaendler, Rummel, Wiedmann, & Spada, 2013), the validation of the TPACK-Practical model (Yeh *et al.*, 2014), the analysis of competency-based learning models (McIntyre-Hite, 2016), the identification of a framework of good practices for online teachers' professional development (Mohr & Shelton, 2017) and the development and assessment of the guiding principles of interaction in adaptive online learning environments (Çetinkaya, & Keser, 2018).

#### AQ4

In these and other studies performed using the Delphi technique, a series of conditions have been established that must be considered to ensure adequate planning and execution. Rowe and Wright (1999, cited in Snelson, Rice, & Wyzard, 2012) indicate the characteristics that must be fulfilled in a classic Delphi study: (1) The anonymity of Delphi participants that allows free expression of ideas and opinions; (2) Iteration that enables participants to examine or modify their views based on the opinions of the expert group; (3) Controlled feedback informing participants of the other participants' ideas; and (4) Statistical analysis that allows a quantitative study of data.

However, the flexibility of the Delphi technique has led to methodological variations that differ to varying degrees from classic Delphi, such as policy Delphi, decision Delphi, real-time Delphi, e-Delphi, technological Delphi and disaggregative Delphi (Keeney, Hasson, & Mckenna, 2011). These versions adapt the process to the subject being analysed or to other conditioning factors that must be considered, such as geography.

#### AQ5

In addition, the level of use of a specific methodology for the treatment of data allows us to distinguish between quantitative and qualitative Delphi. Brady (2015) notes the gap between qualitative Delphi analyses and the scant theory that supports it and guides its practice, especially concerning the reduction and analysis of the data, as well as in safeguarding the rigour of the research. To deal with the first problem, for data analysis Brady (2015) advocates a systematic and controlled process that involves identifying concepts and categories. Starting from the specific expression that is manifested in the responses of the participants to arrive at the themes or general ideas which permit the identification of relationships, linking and organizing concepts, while also relying on the existing theoretical framework and panellists' feedback (Bazeley, 2009; Strauss & Corbin, 1998). As for the guarantee of rigour, Brady (2015) points out the iterative nature of Delphi consensus agreement and adds the development of a methodological diary detailing all the procedural steps taken, as well as a final review of the conclusions by the panellists. In this same field of the qualitative Delphi, Päivärinta, Pekkola, & Moe (2011) introduce analysis techniques from Grounded Theory in a modification of the classical method called the

Grounded Delphi Method (GDM), which according to the authors, would be appropriate for identifying causes and consequences of the topics investigated as evaluated by the experts. Given these differences in the technique, Skumolski, Hartman, and Krahn (2007) point out:

The “typical” Delphi process that we follow in the Project Management Specialization Programme is a general guide rather than a template. That is, we modify the process to best answer our research questions. For example, different types of questions (closed/open) and analysis (qualitative/quantitative) can be used in each round. (p. 5)

In other words, the choice of qualitative or quantitative methodology in Delphi must be based on the research questions.

One of the salient aspects of the Delphi technique is the importance of the panel members. One consequence is that selection of experts is a fundamental element to ensure the validity and adequacy of the Delphi. Despite the lack of a universally valid criterion for the selection of an expert panel (Sackman, 1974), the theoretical recommendations described by Adler and Ziglio (1996) or Skulmoski, Hartman, and Krahn (2007), have been seen in other research (Cortina, 2011; Dixon-Thomas, 2012; Heyman, 2010) and are considered valid references for the configuration of the panel. According to these authors, there are four conditions that the members of a panel must meet to be considered experts: (a) knowledge of the research topics and real involvement in them, (b) the ability to contribute to the exploration of the problem and their willingness to do so, (c) confirmation that they will devote enough time to the exercise of Delphi and (d) possession of communication skills and expression of priorities through voting procedures.

### **Sample: panel description**

In our expert panel, the members were university professors who were also researchers with numerous scientific publications to their credit, which ensured that the panel was capable of making valuable contributions to this study. In addition, all members agreed to participate in the study when invited and showed genuine interest in collaborating by being aware of the complex characteristics of the object of study.

Knowledge of the subject, and a real involvement in it, is the first condition required by Adler and Ziglio (1996). Our initial criterion of choice was participation in conferences on learning ecologies or having written articles about the subject. We selected eight panellists through this criterion. Subsequently, another 4 members were added by means of a snowballing extension (Creswell, 2003) which finally produced a panel of 12 expert members in the first round, with 10 remaining in the following round and 9 in

the final round. Table 1 shows participant demographic data in each of the three rounds including gender, profession, country where they work and academic qualifications.

Table 1 Demographic characteristics of experts

Demographic variable	1st round	2nd round	3rd round
<i>Gender</i>			
Men	6	5	4
Women	6	5	5
<i>Profession</i>			
Professor	12	10	9
<i>Country of work</i>			
Canada	3	1	1
Spain	7	7	7
UK	2	2	1
<i>Academic degree</i>			
PhD	12	10	9

All participants had more than 10 years of experience as university professors and researchers in the educational field. Their workplaces represent nine public and private universities in Europe and North America.

The experts' academic qualifications and scientific careers lead us to conclude that the panel was highly qualified and well disposed to participate in the Delphi on Learning Ecologies.

There is no established minimum of panellists required for the procedure (Akins, Tolson, & Cole, 2005; Avella, 2016; Day & Bobeva, 2005). However, we must consider the warnings of authors such as Okoli and Pawlowski (2004) who suggest that the group should not be excessively large in the interests of better communication management and greater ease in achieving the objectives. Dalkey, according to Linstone (1978), considers seven experts to be sufficient.

### **Survey rounds**

Another important decision in the design and development of the Delphi are the rounds or iterations that will be carried out with the experts. Classic

Delphi proposals have had from four to seven rounds (Young & Hogben, 1978, cited by Yeh *et al.*, 2014), but currently two or three rounds are the norm in order to control and minimize time, cost and participant fatigue and thus produce higher quality results (Hasson, Keeney, & McKenna, 2000).

Below, the three rounds that constituted the Delphi on the components of learning ecologies are explained.

Once participants had shown an interest and confirmed their willingness to participate, they were sent an email with a brief presentation of the study and an explanation of the commitments that were expected from their participation in the study.

### **First round**

The questionnaire contained four open-ended questions. When creating this questionnaire, we considered the fact that the usual classical Delphi choice of posing a single open question carried with it the risk of producing a huge range of answers, especially considering the already diffuse nature and relative novelty of the topic being analyzed. The second approach of closed questions did not offer any guarantees either, as it could conceal bias on the part of the researcher due to the existence of prior initial categorization of the possible answers, as well as the possibility that the researchers could overlook fundamental aspects of the investigation (Keeney, Hasson, & McKenna, 2011). Therefore, we opted for the choice described by Eggers and Jones (1998), of constructing the initial questionnaire based on the existing theoretical framework on learning ecologies, without circumscribing possible answers, but rather encouraging the possibility of specific responses on the part of the panellists.

#### **AQ6**

Once the questionnaire was drafted, it was submitted for validation to a group of six experts in educational research methodology who were not on the panel, so that they could judge each of the issues in terms of interest, relevance, comprehensibility and grammatical correctness.

The first round questionnaire, as finally formulated, was intended to make a brief primer in the still diffuse concept of learning ecology, sparing the experts the effort of building a complete, defined theory on the subject. In other words, our intention was for the panellists to list the ideas that they thought played the most important roles in their concepts of ecologies. The questionnaire sought to gather concrete data on the characteristics of the idea of learning ecologies and the role that technology plays in them, as well as to identify the possibilities (affordances) and the educational limitations that it leads to in the educational field.

Once all the answers to these four questions were collected, we began the

study of the information through a qualitative procedure (Skumolski & Hartman, 2007). The process was structured in two phases: first, the responses were thoroughly and comprehensively read to identify the most significant content areas and subsequently, using the qualitative analysis software ATLAS.ti (Hwang, 2008), we began the attribution of these content areas to specific conceptually supported codes. This fits perfectly with the Delphi rounds needs analysis, as explained by Keeney, Hasson, and McKenna (2011). The purpose of this procedure is to group the answers with similar meanings in broad topics, and then decide which are kept in each area because they contribute unique, sufficient content and which are eliminated because they are redundant or repetitive. The codes, therefore, become an instrument for the construction of those areas that in some cases end up becoming dimensions.

AQ7

It should be noted that the responses were very rich and gave us an awareness of the multidimensionality and diversity of perspectives and approaches from which Learning Ecologies can be observed, analysed and evaluated. Through the qualitative analysis, we saw a broad consensus among the panellists on the following ideas linked to learning ecologies: (1) In learning ecologies, different training systems are interrelated (formal, informal and non-formal); (2) In learning ecologies, different training modalities are integrated (face-to-face, virtual and mixed); (3) In learning ecologies, the interdependence of factors derived from the life trajectory of the learner is assumed; (4) Learning ecologies promote a holistic and integrating vision of learning; (5) Self-regulation mechanisms are used in the construction and development of learning ecologies; (6) The concept of learning ecology is useful as an instrument to improve training processes; (7) Learning ecologies conceptualize the learner as a manager of their learning throughout life and (8) Learning ecologies allow us to recognize and articulate the multiplicity of opportunities and resources for learning.

It was only in the last of these eight ideas that we found discrepancies when it came to identifying available opportunities. In particular, we found a wide range of views about the components making up ecologies.

## **Second round**

The email sent to the panellists included feedback (with the consensus results and the disagreements that emerged in the first round), along with a questionnaire with the questions for this second round to be answered and returned by email. This second questionnaire addressed two blocks of questions: (1) for each of the eight consensus ideas from the first round participants were asked to contribute their perspectives as to how to take advantage of and transfer these aspects to initial teacher training. (2) The other consideration was the question that had produced disagreement and diverse answers from the panellists in the first round which was directly and

specifically raised. Given the purpose of this paper, we will only look at the answers to this final question from the second round: What would be the components making up the ecology of learning today?

The answers to this question were analysed and coded again following the same procedure outlined above for the treatment of the issues in the first round. After the corresponding qualitative analysis through ATLAS.ti, 40 elements were identified that, according to the panellists' answers, could be considered components to include in the analysis of learning ecologies. These 40 elements were considered in the preparation of the third-round questionnaire.

### **Third round**

The third round was performed via a questionnaire with the following question: "indicate how important you think each of these elements are as key components of learning ecologies." Below the question, there was a list of the 40 elements that had emerged in the second round as ecology components. Each of those elements was scored on a 6-point Likert scale (1 = unimportant; 6 = Very important).

After analysing and coding the results of the third round, we proceeded to close the Delphi by verifying an acceptable level of agreement among the panellists in their assessment of the components of the learning ecologies. The components of the learning ecologies and the results of the third round Likert questionnaire are described and analysed in the following section.

### **Findings**

As explained in detail in the previous section, eight ideas were identified in the first round as the result of consensus among all the panellists, although in one of these questions there were also notable discrepancies when identifying the components that make up ecologies of learning. That was the critical issue examined in the second round. In the second round responses, we distinguished 40 possible components of learning ecologies, which were included in the items in the questionnaire in the third round, using a Likert-type format with closed questions. The analysis of the responses in the third round was carried out from a quantitative perspective and descriptive statistical analyses were completed.

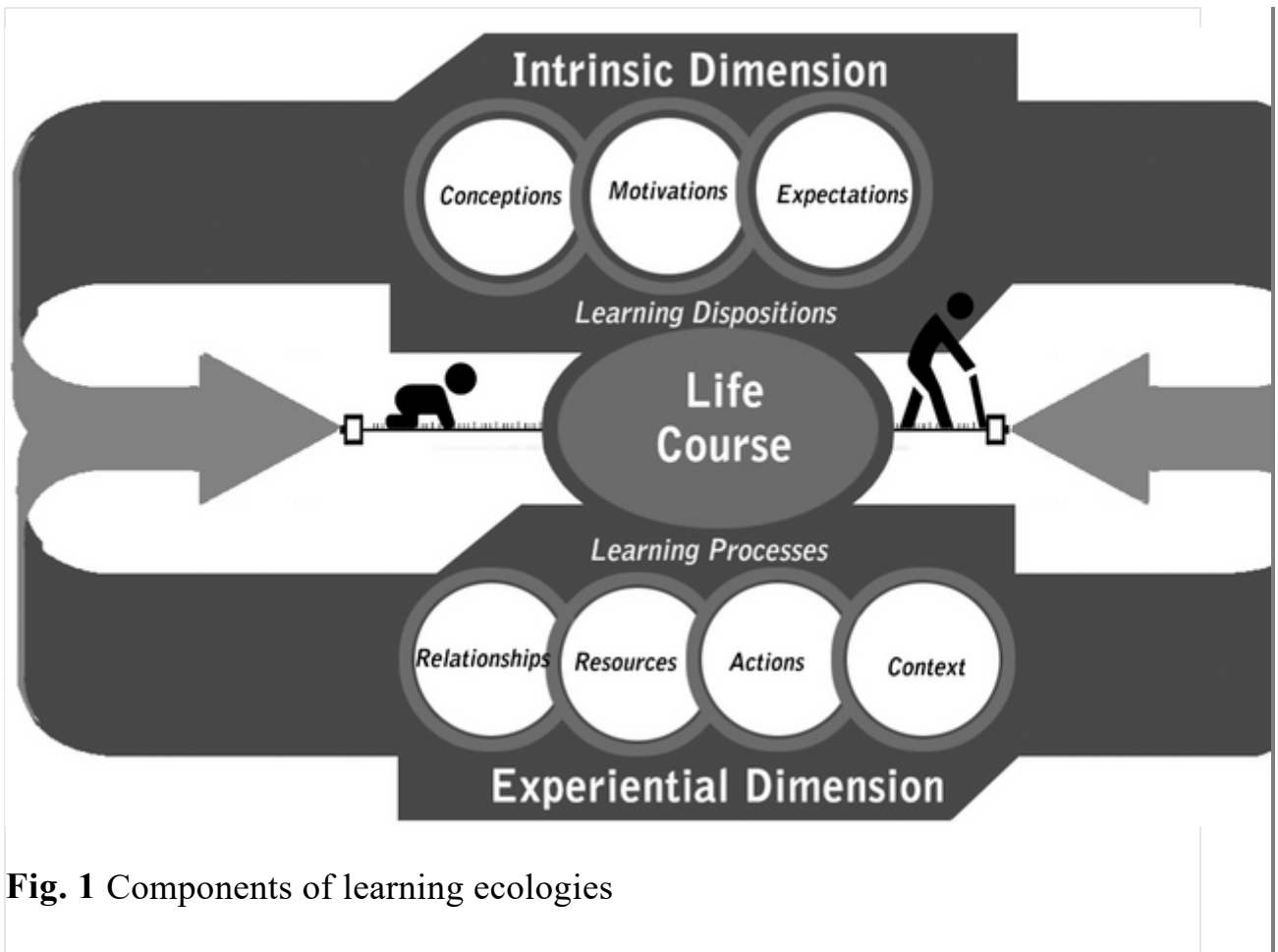
Table 2 shows the mean scores and the modes for each of the 40 items in the third round questionnaire. Following criteria used in other studies (Mckenna, 1994; Von der Gracht, 2012), consensus was based on two criteria: those components with mean scores of 4.5 or higher; where the mode was equal to or greater than 5. Applying these criteria identified 29 elements with greatest agreement between the panellists (in italics in Table 2). Subsequently, with the aim of reducing and restructuring the list of these 29 components of learning

ecologies, the researchers performed a content analysis to describe semantic groups and merge elements with similar meanings. As detailed below, this process led us to identify seven key components of learning ecologies that operate in two dimensions that the “life course” turns on. This readjustment also gives us an overview (Figure 1) which, while respecting the Delphi process and the panellists’ responses, takes account of the contributions of the literature on the components of learning ecologies.

Table 2 Mean scores and modes for the items in the third round questionnaire

<b>Components</b>	<b>Mean</b>	<b>Mode</b>
1. Learning expectations	4.56	5
2. Readiness for learning	4.89	6
3. Learning styles	3.00	1
4. Motivations	5.00	6
5. Self-regulation	3.78	1
6. Conceptions	4.56	5
7. Willingness	3.56	3
8. Desire for learning	3.67	4
9. Self-concept	3.44	4
10. Self-confidence	3.56	1
11. Emotions	3.89	1
12. Interpersonal relationships	5.52	5
13. Capacities	4.00	4
14. Learning goals	3.78	1
15. Interactions with objects	4.89	5
16. Network interactions	5.11	5
17. Actions	5.33	6
18. Strategies	4.89	6
19. Learning processes	4.78	6
20. Activities	5.44	5
21. Tasks	3.56	4
22. Technological tools	5.22	6

23. Materials	4.89	5
24. Resources	5.00	5
25. Influences	3.67	3
26. Personal context	5.00	6
27. Family context	4.89	6
28. Sociocultural context	4.89	6
29. Professional context	5.22	6
30. Academic context	4.89	6
31. Life experiences	5.00	6
32. Life course	4.67	6
33. Physical spaces	4.56	5
34. Virtual spaces	5.00	6
35. Face-to-face learning environments	5.00	6
36. Blended learning environments	4.89	5
37. Virtual learning environments	5.00	5
38. Formal learning settings	5.00	6
39. Non-formal learning settings	5.00	5
40. Informal learning settings	5.11	5



**Fig. 1** Components of learning ecologies

## Discussion

Before describing the key components of learning ecologies set out in Figure 1, there is an important point to make: singling out and isolating each of the components is only for analytical purposes. Each of these elements is linked in networks of relationships with others for learning and they lack any functional sense taken in isolation. For example, *actions* are developed through *resources*; *Personal relationships* can function as learning *resources* and be linked simultaneously to *activities*. Also, an *action* is executed with certain *expectations* of achievement. If we want to account for this whole network of relationships, we should reintroduce them into the corresponding contextual or inter-contextual sphere.

The components have been grouped into two dimensions in view of their characteristics, origins and projection. The *Intrinsic Dimension* includes those aspects more related to internal character that represent a disposition for learning, and the *Experiential Dimension* includes other elements that are part of the person's learning path as a result of their successive *learning processes* throughout the *course of their life*.

The following components stand out in the Experiential Dimension, which is nurtured and configured through each individual's learning path:

*Actions* (which includes *activities* and *strategies*) refers to the specific events

and experiences that mediate learning. They can be produced in any setting, be it formal, non-formal or informal. Regardless of the environment in which they occur, the learning actions generated by the learner's personal interest and initiative, in addition to serving as a path to knowledge, are key to entering other contexts and consequently play an essential role in the development of the learner's identity. Learning actions, when understood as successive in time, constitute learning strategies (Jackson, 2016). Barron (2006a) uses the label learning activities and groups them into five different strategies, which involve: obtaining textual information, the creation of informal interactive activities, exploration of technological means, a search of formal or non-formal learning and construction of knowledge networks. As we said in our introduction, we cannot separate the actions of motivation, interest, expectation or objective (Biesta & Tedder, 2007; Kaptelinin & Nardi, 2006; Leontiev, 1978).

*Resources (materials and technological tools)* are mediators of the subject's activity directed towards the learning objective and are defined by their different way of interacting with the context. Material resources are concrete objects, such as books, websites, a laboratory or any device whose strategic use can serve to generate knowledge in the person (Jackson, 2016). But there are also social and relational resources, in the social sphere, such as those in the family environment or in dealing with colleagues; ideational resources (Sharar, 2016), which are born from the incorporation of elements of the learner's prior cultural experiences, which are halfway between the subject's internal sphere and the contextual constraints which the individual has around them (Cote & Levine, 2014); and identity resources (Nasir & Cooks, 2009). These last two types of resources represent one more argument for the interrelationship between the ecological components, in this case from both experiential and intrinsic dimensions. We can say that resources are dynamic entities that interact and modify each other to a greater or lesser degree. The use of computers (material resources) can lead the student to find a network of people (social resource) that allows new learning, and that in turn generates initiatives in the subject (ideational resources) which develop and strengthen the learner's interest in the object, positively transforming their concept of self-efficacy (identity resource).

When it comes to *interpersonal relationships*, we must infer that people who make up family spaces, peers, teachers and generally those who make contact with the learner and contribute in some way to encourage learning would become part of their learning ecology. According to Barron (2006a), there are several forms of interdependence in the functioning of social relations: they are linked to different learning activities to form relational resources, which we saw in the previous section; they constitute the fundamental base for the construction of knowledge networks, one of the typical strategies in learning ecologies; and they also play a determining role in the genesis and persistence of learning ecologies. We have included *interactions with objects* and *network*

*interactions* in this component.

The idea of *context* is fundamentally inductive because it is constructed from the presence and interplay of the core ecological elements that we have described, both experiential and intrinsic, and the latter especially requires the existence of a learning objective (implicit or explicit) that generates and gives meaning to its internal dynamics (Kaptelinin & Nardi, 2006; Leontiev, 1978). We could develop a contextual taxonomy depending on a study of context (*personal, family, sociocultural, professional or academic*). If we consider the greater or lesser structuring in contextual relationships, we could distinguish types of learning settings: formal, non-formal and informal. With technological resources, we find technologically mediated learning environments or technology-rich environments (*face-to-face, blended and virtual learning environments*). The multiple combinations in quality and quantity of constituents and relationships differentiate one another's contexts. Home, school, work, colleagues, church and any minimally structured social order constitute contexts, whether they are located in *physical* or *virtual spaces*.

Finally, there is a third level of inter-contextual relationships that gives full meaning to ecological theory. Experience shows that often a real learning objective is not fully satisfied in a single context, but can appear distributed across multiple settings, as in the expansion of learning actions through different spaces which characterize distributed environments. There may yet be a variety of contexts and objectives which puts us in the perspective of life-wide learning, or they might be located longitudinally along a person's life, as in lifelong learning. Finally, we may even see how the subject intrinsically generates contexts that offer genuine opportunities to manage their learning, as the heutagogic (Blaschke, 2012) and rhizomatic views suggest (Cormier, 2008).

The Intrinsic Dimension, which brings together various aspects that emerge and have an impact in a reciprocal and bidirectional manner, is shaped by intersubjective elements that characterize the self as a subject that learns and that, in some way, fosters a disposition for learning that manifests as a substrate of learning ecology.

**AQ8**

The Intrinsic Dimension influences and is influenced by the components of the Experiential Dimension that articulate the individual's life trajectory. People are not passive subjects but choose to perform certain activities in the context of opportunities in which they live (Biesta & Tedder, 2007; Elder, 2001). These choices are not conditioned only by external structures, but subjective or intersubjective aspects come into play, which include the individual's interpretation of contexts, resources, relationships and actions within their reach. These ecological components intrinsic to the individual

have a well-established tradition in our field: motivation, conceptions and expectations about learning as relevant factors for the individual's decision to get involved in activities and learning contexts. An individual's conceptions (linked to their motivations and expectations) are closely related with their perception of self-efficacy and their causal attributions, and play a significant role in execution and coping processes for a given learning task. Motivations include various aspects, notable among which are the role of goals and expectations of self-efficacy (Linnenbrink & Pintrich, 2003) which lead learners to involve themselves in and take on various kinds of tasks.

AQ9

Taking all of those questions into account, our model would be in the Pintrich (2003) line, which according to Eccles and Wigfiel (2002), incorporates:

Student entry characteristics (such as prior achievement levels); the social aspects of the learning setting (eg, the social characteristics of the tasks and the interactions between students and teachers during instruction); several motivational constructs derived from expectancy value and goal theories (expectancies, values and affect); and various cognitive constructs (eg, background knowledge, learning strategies, and self-regulatory and metacognitive strategies). (p. 125)

## **Implications and limitations**

The experts who participated in this Delphi have contributed productive and fruitful collective intelligence from which they have discerned vital aspects of learning ecologies that have led us to compose a model that we hope will be both theoretically and practically productive.

Our results and the model we constructed constitute an exciting starting point for promoting future studies in the field of empirical research, fostering new ideas and generating guidelines for acting at the individual and institutional level. While the data and conclusions are not generalizable, they do make a considerable contribution to the complex framework of learning ecologies. They also raise new questions and challenges to continue exploring its meaning and implications in the necessary awareness of each learner and in the indispensable commitment of organizations that design, certify or validate training aimed at personal and professional development.

The identification of the components of learning ecologies has clear implications for the self-direction of learning. It helps each person to be able to take advantage of formal, non-formal and informal learning opportunities in the diverse environments in which they move, thanks to the relationships they establish and the resources they use to do their daily tasks, professional activities or training activities. All this from the intrapersonal substrate that

has been forged during each life path and as a result of the personal characteristics that influence and are influenced by one's life history.

Teachers and students must be aware of the need and desirability of broadening the micro-system in which formal learning happens in order to encourage exchanges and connections with various elements that make up the meso-, exo- and macro-systems (Bronfenbrenner, 1994). As Savin-Baden (2014) indicated, making these interconnections easier would contribute to expanded, more fluid learning.

We can discern two significant implications at the teacher level: one is that the perspective of learning ecologies allows teachers' professional development to be understood with a much wider and richer view, in line with the idea of life-long and life-wide learning (González-Sanmamed, Santos, & Muñoz-Carril, 2016). The other is teachers as instructional designers who, when it comes to organizing their students' learning, must bear in mind the various components of the learning ecologies model so that their proposed training is in accordance with the digital society, which demands more flexibility, personalization, interaction and collaboration, and in that way achieves better learner involvement.

When it comes to students, it is worth noting that "the ecology for learning model positions students as active agents contributing as producers of their own development throughout their lifetime" (Kek & Huijser, 2017, p. 28). Researchers such as Jackson (2013) emphasize the desirability of educational institutions that are committed to supporting and enriching their students learning ecologies.

From the institutional point of view, the components of learning ecologies should be addressed to promote more valuable, authentic and satisfactory learning. In order to achieve this, attention must be paid to the various elements that come into play when attempting to facilitate learning and promote growth throughout all parts of a person's life, taking into account their idiosyncrasies and taking advantage of the conditions of available environments, the most favourable resources and the beneficial interactions that emerge in the course of each person's life.

At the level of instructional design, models such as Agile respond to the perspective of learning ecologies by paying particular attention to the various learning resources, taking advantage of the affordances offered by different contexts and considering student experiences from the length and breadth of their life trajectory. An example of this may be seen in the work by Kek and Huijser (2017), about the Agile Problem Based Learning ecology for learning.

Finally, it is worth mentioning some of the limitations of this study due to general conditions in the use of the technique and the specific aspects of the

process followed. As already indicated, the requirements about the experts and the iteration rounds were followed in order to guarantee the rigour and validity of the Delphi. In any case, perhaps it might be beneficial for future research to expand the number of panel experts, and strive to have a wider geographical spread and more variety in panellists' academic and research backgrounds.

**Acknowledgements** The research has been partially funded by a grant received from a competitive call for research projects carried out by the Spanish Ministry of Economy and Competitiveness.

For this reason, we would like to indicate clearly in the section Acknowledgments that the institution that has given us the funding is the Spanish Ministry of Economy and Competitiveness.

And specifically, to make it more visible, we would request changing the original text that we send at first for the new one that we are sending now:

We thank the Spanish Ministry of Economy and Competitiveness for their support of our study under a research project entitled "How the best University Teachers Learn: Impact on Learning Ecologies on Quality of Teaching" (ECO4LEARN-HE) (Reference: EDU2015-67907-R).

Thank you very much in advance for your kind attention and disponibility.

Yours, sincerely, the Authors.

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We thank Government of Spain (MINECO) for their support of our study under a research project entitled "How the best university teachers learn: impact on learning ecologies on quality of teaching" (Reference: EDU2015-67907-R).

### **Statements on open data, ethics and conflict of interest**

Data can be accessed by contacting the author.

Ethical approvals were gained from the participants.

No conflict of interest declared.

### **Funding Information**

Secretaría de Estado de Investigación, Desarrollo e Innovación	EDU2015-67907-R
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