Sustainable Use of Ecological Concepts in Educational Science

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Abstract

In this article, the authors discuss the use of ecological concepts (ecology, boundary, niche) in educational research to understand if and how these concepts from one field of science (ecology) can bring a new understanding to another field of science (education). We have conducted a systematic search in the ERIC database to identify articles where key concepts from ecology, such as ecosystem, boundaries and niche, are used in educational research. An algorithm inspired by Rodger's (2000) contextual model of concept analysis was used to examine how the concepts contribute to explore, explain or understand an educational system or an educational process. We find that the use of ecology-oriented concepts is related to a circular rather than a linear causality between actors and environment and between thoughts and actions. Thus, an ecological educational approach is characterised by wholeness, and emphasizes context as well as the complex interconnected mechanisms in educational processes.

Key words: ecological pedagogy, boundaries, niche, concept analysis

Introduction

For something to be sustainable, the resources, whether human, economic, social or environmental, must be managed in a way that safeguards the whole and is appropriate for the future. The term is widely used; all human activities can be linked to sustainability. It also applies to the field of education, expressed as "sustainable education" (Lykke, 2019) and "sustainable learning" (Eskici, 2019). This systemic understanding is related to an ecological view on systems.

In this article, we address several concepts related to ecology: *ecosystem, boundaries, boundary crossing* and *niche*. We explore the use of these concepts in educational research to understand if and how these concepts from one field of science (ecology) can bring a new understanding to another field of science (education). We want to find the answers to the following questions:

- How common are these concepts in educational research?
- How and in which contexts are the concepts from ecology used in educational science?
- How can the concepts from ecology contribute to understanding in educational science?

Research Method

Using an exploratory concept analysis, we aim to clarify the nature and meaning of the above-mentioned concepts used in educational research. The Education Resources Information Center (ERIC) database is a comprehensive, searchable, Internet-based bibliographic and full-text database of educational research with access to 1.5 million bibliographic records (citations, abstracts and other pertinent data) of journal articles and other education-related materials. We conducted a Boolean search of the terms *ecology, ecosystem, boundary, boundary crossing* and *niche*, using the following filters: publications that were 1) written in English 2) between 2015 and 2019 and 3) peer reviewed.

We first discarded all articles containing biology as a keyword to avoid biology-oriented articles. We then respectively used *teaching, learning, education* and *teacher education* to narrow the search for each of the concepts. We reviewed the first 20 articles in each search, such as 20 for ecology and teaching, 20 for ecology and learning, and so on. Our purpose was to identify those articles that apply the concepts in a substantial manner, where the terms are used to explore, describe, explain, understand or analyse pedagogical practice. The articles in which this was not the case were then excluded. An article concerning a programme for biology teachers discussing the greenhouse effect and an article describing a school project on ecosystems were set aside. Our search in ERIC generated the results shown in the table below.

Table 1

Number of Articles Containing Concepts Related to Ecology

Concepts in the articles:	Ecology	Ecosystem	Boundary	Boundary Crossing	Niche
Ecology	906	278	469	70	85
NOT Biology	820	251	469	68	85
NOT Biology AND Teaching	300	95	155	27	28
NOT Biology AND Learning	417	137	207	43	37
NOT Biology AND Education	693	217	404	55	79
NOT Biology AND Teacher education	48	10	46	35	2

The articles using the concepts explore, explain or understand an educational system or an educational process in a systematic way were further investigated by applying the following algorithm inspired by Rodger's (2000) contextual model of concept analysis:

- Identify multiple uses of the concepts and develop operational definitions.
- Determine the concepts' defining attributes and characteristics.
- Identify model cases from the literature to exemplify these in practice.

Ecologic and Systemic Understanding of Educational Processes

Ecology is the scientific study of the distribution and abundance of organisms, the interactions among them, and the interactions between organisms and their environments. Ecologists try to understand the inner workings of natural ecosystems and the species they contain. All organisms interact with their environments. If we look at a delimited

area of nature, such as a lake, we find that all the organisms there affect one another. This whole system, consisting of a multitude of organisms, plants, animals, fungi, micro-organisms, nutrients, water and various climatic factors, is called an ecosystem. The organisms compete within such an ecosystem (Campbell et al., 2008), and if the system is in balance, it is sustainable.

The concept of ecology is widely used in educational science. A pedagogical ecosystem describes the mutual dependence among its parts. According to Hutchins (2010), since the 1970s, three main traditions have committed to a cognitive ecosystem as the unit of analysis: the ecological psychology (Gibson, 2015), the ecology of mind (Bateson, 1972) and the cultural-historical activity system (Cole, 1996; Vygotsky, 1978). Hutchins' (2010) presentation of the history of ecological approaches to education underscores how teaching and learning mutually influence action and the surroundings. Being both a biologist and an anthropologist, Bateson (1972) uses ecology as a metaphor in his descriptions of educational systems. In his book, *Steps to an Ecology of Mind* (1972), he describes the elements of social ecosystems as interconnected and interdependent, similar to biological ecosystems. Bronfenbrenner's (1996) ecological model explains how the inherent qualities of children and their environments interact. The model describes different levels, from the microsystem, through the mesosystem and the exosystem to the macrosystem as an outer cover of norms, values and ideologies. The levels relate to and influence one another; hence, all humans are part of complex interrelated webs. This theory offers a systematic way of understanding the context of each individual.

Search for Ecology in Educational Science

A search in the ERIC database for "ecology" reveals 906 articles containing the concept. Ecosystem is less frequently used, with 278 hits. When the articles using biology as a term are omitted, 820 and 251 articles remain, using the respective concepts. The search implies that the concept of ecology is used relatively extensively in the field of education. However, a review of the articles displays a preponderance of articles about learning and teaching ecology. Fewer articles use ecology or ecosystem as a concept describing the systems framing the teaching, learning or education. We have selected two examples of such articles.

The article by Lopes, Boyd, Andrew, & Pereira (2014) discuss about professional identity construction as an ecological concept. They propose an ecological approach to understand the research-teaching nexus and the construction of identity for student nurses and student teachers. The authors relate the construction of identity to ecology in this way:

> *However, no such situation – in terms of practices, interpretations and challenges – is independent of its broader contexts. Professional identity is therefore an ecological construct (Lopes, 2009), with the term "ecological" borrowed from Urie Bronfenbrenner's ecology of human development – which theorized both the constitution and the dynamics (interaction, within and between subsystems) of the ecological system and the role of scenarios and the individual (Lopes et al., 2014, p. 170).*

The authors express a broad understanding of the interactions among systems from an ecological perspective when they cite Blin: "[...] the complex system of relationships

between individuals, groups and institutions is determined not only by intra- and inter-personal variables, but also by a social field giving it a specific form and leading to behaviours that are socio-cultural in nature" (Blin, 1997, p. 56, as cited in Lopes et al., 2014). Their study adopts Blin's ecological perspective on identity construction as an analytical framework (Lopes et al., 2014, p. 170).

Butler, Storey, and Robson (2014) develop the term "emergent learning focused" (ELF) teacher to describe the sports teacher who grasps the learning possibilities arising from spontaneous play. They define ELF teachers as those who encourage learners to develop holistically. The ecological view is related to the holistic construction of meaning, ownership of the games played and "cognitive apprenticeship that prepares them [the pupils] for life in the wider community" (p. 451). In Butler and colleagues' research, ecology is a basic value when working as a teacher and a researcher.

In the two cited articles using ecology as a substantial concept, the researchers define an ecological approach as involving a holistic understanding of the relations between individuals and their contexts. Ecological education and ecological teaching can then be superior terms relating to many different approaches characterised by wholeness and coherence. The researchers use ecology to describe systems with high internal, local interactions. In this respect, ecology can often be interpreted as characterized by internal coherence when used in educational scientific papers.

Boundaries in the Field of Ecology and in the Educational Research

The scientific explanation of a boundary is as a contact zone between different ecosystems (Cadenasso, Pickett, Weathers, & Jones, 2003; Strayer, Power, Fagan, Pickett, & Belnap, 2009). The boundary zones have components from the various nearby ecosystems, and normally, a great diversity of organisms is found in the zones (Strayer et al., 2009). In the field of ecology, this zone is also called ecotone and may be narrow or wide. It is more often a zone than a borderline. The flow of organisms, materials, energy and information between different ecosystems, crossing the boundaries or living in the zone on the edge of the established ecological patches, seems to offer some extra possibilities. While boundary as an ecological concept describes the area between the patches of ecological systems, it defines the connections between individual, social, cultural and educational fields in an educational context (Akkerman & Bakker, 2011; Engeström, Engeström, & Kärkkäinen, 1995). In both ecological and educational systems, we find energy, materials, communication and organisms crossing boundaries.

Search for Boundaries

The authors search in the ERIC database for "boundaries" reveals 469 articles containing the concept. When the articles using biology as a term are omitted, we find that the same number of articles use the concept. The search implies that the concept of boundaries is used relatively extensively in the field of education. The interest in boundaries aligns with the study of larger units of analysis. Star and Griesemer (1989) state the need for ecological analysis that includes analysing the various institutions and viewpoints of the actors involved, to understand how boundaries are encountered and crossed.

Likewise, Engeström, Engeström, and Vähäaho (1999) show that studying boundary crossing requires an analysis of all the loosely connected systems involved. This extended scope of analysis has been an explicit part of what is referred to as the third generation of cultural historical activity theory (CHAT), which states that two activity systems form the minimal unit of analysis.

The articles using the concept of boundaries or boundary crossing describe boundaries between institutions, such as schools and universities, and in the working life. The articles describe patterns of interactions and practices, especially in professional development and school leadership. Transformations of practices are highlighted. The concept of boundary crossing retains some of its original meaning from ecology, used in an educational setting. However, in education, the emphasis is on development and learning, whereas in ecology, the focus is on adapting. We have chosen representative articles as examples of how boundaries are used in educational research. Akkerman and Bruining (2016) discuss the concept of boundary crossing which is used for exploring the challenges of professional development – school partnerships as endeavours to cross institutionally and epistemologically developed boundaries between teacher education, schooling and academic research. The case study narrative illustrates the multilevel and intrapersonal nature of boundary crossing by showing various brokers' significant and challenging role in establishing both horizontal and vertical connections across and within the organisations involved. Mooney Simmie and Lang (2018) refer to boundary crossing in relation to the activity theory as a framework for opening a deliberative enquiry in new discursive spaces to elicit gender awareness in teachers' practices. Köpsén and Andersson (2015) draw on a sociocultural perspective, exploring how vocational teachers' continuing professional development (CPD) implies boundary crossing between school and working life. A theory concerning adults' participation in education is considered relevant for understanding the conditions for such boundary crossing and learning among vocational teachers. Snoek, Enthoven, Kessels, and Volman (2017) emphasizes that the teachers involved in this master's programme started a development process that shifted from formally mandated forms of leadership to more culturally embedded ones. This leads to a new understanding of the design criteria for master's programmes and how boundary objects support the processes of developing teacher leadership. The master's programme serves as a catalyst, stimulating the innovation of work practices and the development of new leadership practices. The study expresses how master's programmes supported by design criteria can facilitate boundary-crossing activities between schools and universities.

The concept of *boundary crossing* describes students' learning between disciplinary and institutional boundaries (Fitzgerald, Gardner, Amey, & Farrell-Cole, 2018), teachers' and learners' experience with objects, such as e-portfolios (Nore, 2015), recognition of prior learning and the tensions between its inclusive intentions and constraints on its implementation (Cooper, Ralphs, & Harris, 2017), new working spaces and new ways to exercise agency and learning (Kersh, 2015), students' learning of interdisciplinary methods (Rienties & Héliot, 2018) and knowledge flow and facilitation (Wang & Wong, 2017). These articles deal with knowledge flow, interactions between knowledge forms and between theory and practice or re-contextualisation and facilitation and the roles of the actors.

Niches in Ecology and in Educational Research

A niche in ecology is the position, way of life or role played by a species in the environment where it lives. It is about how it manages to meet its food and light needs, how it survives and how it reproduces. A species' niche includes interactions with both abiotic and biotic factors in the environment. Biotic factors are all living organisms that affect the species, for example, what it eats, its different competitors and who eats it. Abiotic factors are the non-living, environmental conditions and things, such as temperature, humidity, light, soil, minerals, and so on. An organic niche is the sum of the species' or the population's use of the biotic and the abiotic resources in the environment where the species or the population lives (Campbell et al., 2008). Niche as a concept appears useful in explaining ecosystems, patches and crossing boundaries. In ecology, it is explained as the inhabitant's net of interactions and contacts with other organisms (Halvorsen, 2014). This explanation seems useful in education. The actors create and influence their niches.

Search for Niches

The search in the ERIC database for academic publications using the concept of *niche* in the field of education generates 85 hits. The articles show that the term is used in the educational field in relation to pedagogy of place (Lewicki, 1998), pedagogy of children with special needs (Gallimore et al., 1989; Rice & O'Brien, 1990) and environmental education (Thompson, 1997). In recent years, Kemmis and Heikkinen (2012; see also Mahon, Heikkinen, & Huttunen, 2018) have relaunched the concept in relation to an eco-systemic approach to educational praxis. In her PhD research, Halvorsen (2014) builds her pedagogical understanding of educational partnerships on concepts from biology, choosing ecology and niche as two of these concepts.

Kemmis and Heikkinen (2012) change the above-mentioned original definition of ecology when they use the concept of niche in an educational setting, stating that it "motivates and stimulates" a practice, "providing it with motivations (points of departure), purposes (ends) and the characteristic places and paths in and through which the practice is enacted" (p. 161). In this description, the organism seems conscious about the choices, and a niche is then defined as a human activity, not a more general condition.

Mahon and colleagues (2018) take a step in another direction, away from the ecological definition, by explaining that "the concept of niche refers to the distribution of resources and competitors that are necessary for, or permit, the survival of the organism" (p. 469). Niche is here related to the distribution of resources, a condition influencing the niche. Lewicki (1998) displays a resource-oriented approach to the concept of niche when he writes, "[...] an animal carves a niche in a food chain, so does each student build a niche in your classroom" (p. 10) and elaborates, "Each niche is determined by how a species functions within the food cycle and its adaptation to the general habitat" (p. 23). Transferred to an educational setting, a niche is then influenced by interactions with other persons in a contact net and by the actors forming their niche in social interaction and collaboration. In the field of education, we find that the classroom, the staff room, the meeting between the parents and the teacher, and the team meetings are examples of niches.

Discussion

In our search, we find the concept of ecology in 820 articles and the concept of ecosystem in 278 articles. Boundary and boundary crossing are not as commonly used as ecology, with 469 and 58 hits, respectively, while our search for niche yields 85 hits. However, only a few articles use the concepts to describe or frame teaching, learning or education. In most of these articles, the terms are used in their original meaning and are therefore not of interest in our study. Our goal is to find out how the terms are used as educational concepts. Through our review of selected articles in each group, we have identified the most relevant ones and have shown, through examples, how the terms are used as substantial educational concepts to describe, explain or analyse pedagogical practices.

In the field of education, the concepts of ecosystem and ecology describe a complex holistic context where the elements or the study objects influence one another. This finding indicates that the meanings of the concepts have not changed radically from the original contents of the terms. The abiotic and the biotic factors that make up the ecosystem in ecology have been replaced by people and institutions in educational research. However, the main finding is how the use of ecological concepts in educational research emphasises wholeness over parts and contextualises the studied phenomena. In this way, ecology can be a counterweight to a causal, reductionistic way of arguing.

For the terms boundaries and boundary crossing, the situation is somewhat different. In the original ecological setting, the boundary zones are naturally occurring areas with a great diversity of species. In the educational setting, the boundary zones between different groups, institutions or cultures are constructed, and the reason is to create places for development and learning. In the educational understanding of boundaries, the zones become collaborating areas where participants from different institutions meet and work together. When crossing the boundaries between different institutions to create venues for learning and development, the concept has led to increased emphasis and awareness of the spaces between previously separated entities in the field of education.

In ecology, co-existence in a niche is ruled by the supply of and the competition for available resources. The use of the niche metaphor therefore supports the focus on the dimensions of the resources, followed by an emphasis on who possesses the power to control the resources. The use of the concept of niche underlines the importance of a holistic understanding of the networks of interactions. At the same time, the use of the concept of niche directs attention to the participants as actors and their possibilities of regulating the use of the resources.

Conclusion

According to the different perspectives retrieved from the articles, from an educational standpoint, ecology is related to a circular rather than a linear causality between the actors and the environment and between the thoughts and the actions. Thus, an ecological and educational approach, is characterised by everything being related. Individual reflections and actions are strongly influenced by, and do affect the environment and the cultural traditions. The ecological concepts used in educational research underscore the importance of this wholeness and context, and underscores how complex interconnected mechanisms in society relate to one another.

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