

# Promoting Distributed Cognition at MOOC Ecosystems

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**Abstract.** The paper proposes describing connectivist MOOCs as a learning ecosystem. We highlight two aspects of distributed cognition epistemic and collective – that MOOCs promote and relate these with learning by chance-seeking and learning from ecological enculturation. Finally we outline some design aspects for supporting chance-seeking and learning from an encultured environment in connectivist MOOC ecosystems.

## 1 Introduction

Connectivist MOOCs may be viewed as self-organised ecosystems of learners and digital contents and services, which have good potential for supporting distributed cognition. In this theoretical paper we explain how some of the learning behaviours related with distributed cognition – learning as chance-seeking and ecological enculturation – may be promoted by building on the ecological principles that guide MOOC ecosystems. We outline some design aspects of MOOC ecosystems for supporting chance-seeking and learning from an encultured environment.

## 2 MOOC Ecosystems as Distributed Cognitive Systems

### 2.1 Characteristics of MOOCs as Learning Ecosystems

We define a MOOC as a unit of learning with specified institutional affiliation, schedule, content and learning tasks which engages self-directed and self-organised learners and leading practitioners in the field by fostering open enrollment, open curriculum, open and partially learner-defined learning goals and outcomes, the usage of open resources and open learning environment, and the enabled open monitoring of learning activities (see [1][2]) with the aim of facilitating learning as a process of navigating, growing and pruning connections and interactions within distributed networks, and generating coherence, resonance and synchronisation in knowledge [3]. There is a diversity among MOOC designs – some focus on supporting the development of learners' domain-related knowledge and self-directed learning competences [4,5], whereas others, inspired by Connectivism [6], target rather the emergence of the distributed connective

knowledge networks among learners which should sustain after the end of the course [1,7,2,8]. We see our contribution in proposing the distributed cognitive learning behaviours that are particularly promoted by connectivist MOOCs because of their ecosystem-like functioning.

The MOOC is a learning ecosystem in which we may consider three types of “organisms”: 1) producers, 2) digital “organisms” (such as digital learning contents created by various MOOC users, digital learning tools and services activated as part of PLEs and the big MOOC ecosystem), and c) the digital learning services of MOOCs. In accordance with the ‘produsage’ concept introduced by Bruns [9] we may assume that all users (learners, experts, facilitators) provide the MOOC with some services that enhance learning. ‘Produsage’ concept combines learners production and consumption as inseparable from each other in the surrounding environment. The learning services may be considered as the digital organisms that exist as the symbiosis of digital components and producers. Since different producers target learning differently, they populate the MOOC with particular kind of learning services for their own and their communitys benefit.

Knowledge in MOOCs is operated by as well as is incorporated into the different learning services that the producers activate. Knowledge can flow and become aggregated as a distributed structure in the learning ecosystem, creating new opportunities for ‘producers’ who can remix it repurpose it, feed it forward, or create new knowledge [6,10] and new learning services of it. An example of such learning services is scaffolding services that are created by other learners and facilitators, or that emerge as a result of the accumulation of MOOC participants learning and support activities [11]. For example, the socially annotated and aggregated contents may provide learning support [12]. MOOC learners’ motivation appears as a formation of intention and attention of the resources available in the MOOC in an ongoing coupling between learner’s goals and the affordances they perceive from the environment [13,14]. Considering and using learning services that are currently available in the MOOC ecosystem causes some ecosystem services to compete with each other and others to form alliances, some services increase in numbers while others perish. User attention fuels the knowledge flows through the services, which defines the productivity of learning ecosystems. Abundance and variety of mutually communicating learning services in MOOC ecosystems provided by all MOOC participants facilitates their mutual awareness and participatory surveillance [15,5] which in turn contributes to social embeddedness as a motivating factor of learning [16,17].

## 2.2 Distributed Cognition in MOOCs

MOOCs have a similarity to natural ecosystems also at a distributed cognition level – while in a natural ecosystem the flow and transformation of energy and matter are operated by the trophic network of species, the MOOCs as distributed cognitive networks facilitate knowledge transformations. In a distributed cognition approach Hollan, Hutchins, and Kirsh [18] explain interactions and the coordination of activities between people and technologies assuming that people

form a tightly coupled system with their environments, and the latter serves as one's partner or cognitive ally in the struggle to control the activity. Social organisation is therefore seen as a form of cognitive architecture that determines the way information flows in the context of activity [18].

There are two main ways in which, distributed cognition may be fruitfully framed in MOOCs – epistemic distributed cognition that we relate with chance-seeking, and collective distributed cognition that we relate with learning from ecological enculturation. It is important to note that chance-seeking and learning from ecological enculturation complement each other in the MOOC ecosystem.

**Epistemic Distributed Cognition.** The word "distributed" refers to the fact that humans drastically lean on external resources in solving problems and making decisions. MOOC takes place in a digital (but also a hybrid) distributed learning environment, which is co-constructed by users with different backgrounds, but shared interests. From the user's point of view the emerging infrastructure can be a temporally extended personal learning environment (PLE), which allows the sharing of learning resources (people, artifacts, practices) and goals openly among the MOOCs learning networks. This distributed cognitive system serves as a partially external and uncontrollable locus of control [18] both from the point of view of learners as well as facilitators, and course organisers. In this case, distributed cognition refers to the assumption that one's performance cannot only be confined to what happens within his or her own skull. Conversely, humans continuously offload some of their cognitive functions onto external objects and artifacts, which can just be found out-there or designed for accomplishing specific goals and tasks. In this respect, human cognition functions in an opportunistic way, that is, by seeking out chances to make the most of body and (social) environment [19] and integrating them into unified systems of distributed problem-solving [20]. Distributed cognition considers the interactions of people and the resources in the environment as an emergent distributed cognitive system [18] where internal resources – memory, attention, executive function and external resources – the objects, artifacts, and at-hand materials and software are temporally integrated into goal-based affordance networks [21] that support actions. This kind of distribution is eminently epistemic, because it deals with the very activity of knowing and understanding the world one lives in. Giere [22] refers to this kind of distribution as "locally distributed" cognition. We prefer to call it epistemic distributed cognition (hereafter EDC), because we want to stress the epistemic dimension involved. Characteristic to EDC is that it can only be attributed to individual agents (producers) who are the only ones that are endowed with attributes such as intentions, beliefs, consciousness, and so on. EDC is based on a tacit dimension of knowledge that is different for everyone and influences different chances to be found, creating diversity and variability of using external resources as part of the distributed cognitive system.

**Collective Distributed Cognition.** The second type of distributed cognition may be called collective distributed cognition (hereafter CDC). In this concept the word "distributed" may be applied to cognition where the output of a

certain cognitive process cannot be attributed or tracked back to the effort of a single agent, but it is the product of collective effort. For example, a connectivist knowledge creation is the result of a number of MOOC producers plus various digital artifacts and tools. CDC targets ecological enculturation. Traditionally, enculturation refers to the process by which a person becomes acquainted with a given culture (or community of practice) [23], which may be related with EDC. In our approach, enculturation refers to the fact that part of the environment can be encultured, that is, modified so that it becomes potentially meaningful for certain purposes rather than others. Bardone [19] suggests that human beings act as an integral part of their environment while at the same time actively modifying and constructing this environment. Enculturation brings the traces of previous activities available in some form for future use. We can distinguish between emergent and purposeful enculturation. While emergent enculturation occurs as a product of self-organised system behaviour from the interactions between various types of producers such as in connectivist MOOCs, the purposeful enculturation can be related to pre-designed learning environments and instructional designs.

### 3 Learning Behaviours Related to Distributed Cognition

#### 3.1 Learning as a Chance-Seeker

Many participants of MOOCs do not come to the course with certain objectives in mind, but rather discover them while learning at the MOOC [2]. Learning lies outside the realm of regular expectations and involves a forward-looking attitude. We tend to treat learning as a linear process that can somehow be “directed” and would imply to assume something we do not know yet. This gives the illusion that we can actually control and therefore direct the whole process, when in fact our understanding is based on a mere selection of those past events that help to create a coherent and therefore compelling story. We can easily come up with a causal explanation about how and why learning has occurred. However, that can only happen retrospectively – by looking backward at the process after it came to an end, as many MOOC participants have reported [2]. Incoherence and messiness cannot fit into the linear learning model. We are unable to predict learning events because there is nothing in the past that may reasonably hint at their happening. As Shackle [24] brilliantly noted that all we know about the future is nothing but an inference drawn from the past. We can rely on the past, if we can reasonably assume that the future will resemble the past, but that is never the case. Past events can never be a solid bases for predicting what is going to happen next.

We tend to think that the distribution of cognition in MOOCs, and the subsequent extension of ‘producers ability to solve problems, can only be with regards to the interaction with specific objects, tools and services available at learning environment allowing them for extending their specific abilities. However, little attention has been given precisely to situations in which it is the unanticipatedness of MOOC ecosystem that provides a fundamental aid. We posit that MOOC

participants dynamically evolve the ecosystem producing its unanticipatedness. The idea of environmental unanticipatedness posits that the environment plays an active role in a given course of action, since unanticipated and unexpected events potentially open up the way to new knowledge or information we would not be able to acquire otherwise. Chinese general Sun Tzu in *The Art of War* pointed out that “if we do not know what we need to know, then everything looks like important information”. This means that under conditions of ignorance and inexperience, we can only turn to our environment as a provider of unanticipated and potentially helpful events. We lean on something external to us, something that we basically lack for we must entrust ourselves to something we do not fully or partly control. There is however a crucial difference between environmental unanticipatedness and virtually all other forms of cognitive distribution: we make use of our ignorance and turn to environmental unanticipatedness, when we just do not know; while when we have a precise intent in mind, we can turn to certain patterns detectable in the ecosystem (which we will explain further on).

Learning implies chance-seeking that we introduce here as one of the fruitful distributed cognitive behaviours in MOOCs. Chance-seeking is about how people may come to utilise chance to their advantage and tentatively amplify the unanticipated, yet positive potential, until they create a useful pattern, a potentially replicable solution to the problem for themselves. In this case the learner can identify that he has learned something. In our definition, a chance is any unanticipated event that falls outside of one’s control. Such an event conveys an opportunity for action that appears to have some strategic value in pursuing one’s learning goal. This definition contains three elements that need clarification. Unanticipatedness is related to our inability to guess and predict what is going to happen on the basis of what we know, so as to be prepared beforehand to face the possible consequences. Not all unanticipated events in MOOCs that lead to learning are necessarily chances, but only those, which convey an opportunity for learning. Chance must somehow appear meaningful to the person. One has to identify in a chance event purposiveness and positive significance with respect to personal learning goals. Chance may be of no immediate relevancy for one’s goal, but it may be conceived as strategically useful, because it projects the problem-solving process towards further chances. So, the identification of a chance implies a sense of purposiveness, it is a form of knowing as one goes rather than knowing before one goes [25]. What a MOOC participant actually identifies as a chance is a subjective matter, and its identification depends on several different factors specific to the individual, including his or her knowledge, attitude, personality, and other more contingent and transitory factors like moods or feelings. It is also important to note that a chance is not necessarily a new or surprising happening, because what counts is the way a person makes sense of it in relation to his or her learning goals.

We cannot anticipate that certain happenings in our ecosystem may turn out to be a resource when we are facing an adapting challenge like in the case of learning. We cannot entirely rely on what happened in the past, but we must inevitably look forward, projecting ourselves onto the future, which is by

definition unknown. If we cannot anticipate what is going to happen, we may try to amplify the positive potential of those chance encounters that happen to appear somehow meaningful to us. This process, which is at the heart of chance-seeking, can be characterised as a “deviation-amplifying mutual causal process”. This concept was introduced by Magoroh Maruyama [26] to refer to the fact that the outcome of a process is initiated by an insignificant or accidental “kick” and is then built upon its subsequent amplifications and so diverging from the initial condition. The environmental feedback is so that deviations (in the form of unanticipated/unexpected events) are not counteracting the learner’s work as in the case of following a predefined and planned course of action. Conversely, deviations become a source of mutual positive feedback, which expose the learner to subsequent and potentially positive unanticipated events.

Once a chance is recognised, an action is taken to amplify the potentials of positive significance. This is indeed entirely conjectural and tentative. The action taken on the basis of inevitably marginal, unassorted and apparently irrelevant resources may uncover new possibilities in terms of subsequent chances or novel observations. This process involves iterative circularity. Which means that the amplification of the positive potentials of chance encounters is reiterated until a satisfying solution is reached, if it is reached. By that the learner forms a personally defined distributed space - a cognitive niche. We see chance amplification as the main way of cognitive niche formation. The chance amplification enables to optimize the results of chance-seeking by testing the fitness of each chance encounter in the ecosystem. As an example of chance amplification we can consider a help-seeking service created by the producer in MOOC: he sends to different spaces (Twitter, blog, forum) the same request, modifies the request content etc. until discovering the viable solution how the requests get answered in this ecosystem.

The whole process of chance amplification can be described in terms of tinkering (or *bricolage*). Planning learning mostly relies on knowledge that necessarily must be held in stock before one starts, one may reasonably design for and aim at optimised solutions. What the chance-seeker does is to tinker with chance encounters. In the case of tinkering, it is not possible to identify beforehand that the body of knowledge will turn out to be relevant: one must act flexibly, and be ready to adjust his or her strategy according to contextual elements as they arise. Tinkering with chance events implies that “we only know what we know when we need to know it”, as Snowden [27, p. 110] put it. The process of tinkering with chance encounters is driven by the absence of a plan. The chance-seeker as a tinkerer in MOOC does not subordinate a course of action for making a list of resources one should necessarily have. Tinkering is immediate and contingent upon past events, but with no view to the future [28]. In this respect, creativity emerges by recombining pre-existing resources resonating with chance encounters, as we have noted above. Siemens and Downes [10] have high-lighted repurposing – creating something of their own – as activity learners do at Connectivist MOOCs. They describe at MOOCs the connectivist learning practices of remixing and reflecting on the resources and relating them to what people

already know. In our paper we extend repurposing concept also to the learning services that the learners create as producers. We assume that it is important to emphasise that such repurposing has to involve the element of chance, rather than being purposeful action that leads to linear learning. It is worth noting here that those pre-existing resources used in tinkering and repurposing are never the result of a linear process. Conversely, they are bound to contingent happenings. In the case of tinkering with chance events, solutions are never optimised solutions, but always workable and provisional ones, which may serve more as a springboard to subsequent ones than as end-points and definitive results.

### 3.2 Learning as an Ecological Enculturation

By chance-seeking, the learner can detect one's learning as a personally useful pattern – the solution to his problem. He explores the fitness of this pattern in this eco-system through the process of chance amplification. The result of many chance-seekers self-organised cognitive activities however contributes to ecological enculturation. It is increasing the anticipatedness of the environment by pattern formation. In this chapter we want to discuss patterns from the distributed cognition angle – how they are formed and perceived as part of the encultured environment, and how patterns may influence learning. We want to highlight ecological enculturation and pattern appropriation as second type of distributed cognitive behaviours that are common to MOOC learners.

When we interact with cues in the environment or see the others interacting with it we can recognise the patterns. By definition, a pattern is any regularity that organises what we see in a consistent, regular manner. Alexander and associates [29] define design patterns as the visible/explicit part of a solution to a problem in a field of interest. They assume that patterns tend to focus on the interactions between the physical form of the built environment, and the way in which that inhibits or facilitates various sorts of personal and social behaviour within it [29]. Culture propagates itself with patterns and pattern systems. The patterns are loosely connected across scales: any given pattern typically points to smaller scale patterns which can support it, and larger scale patterns in which it may participate [29].

Several MOOCs designs have incorporated learning analytic elements as part of the course design. It was done with the intention to learn about learning analytics but also with the aim of using learning analytics for making MOOCs more effective, creating the environmental feedback channel for visualizing patterns to the learners. Such learning patterns are apt to guide learners in dynamically making informed decisions and adaptively changing their learning behaviours.

From the CDC point of view, patterns are easily recognisable generalisations of solutions for a problem, that emerge as the contingent result of all the occasions there have been to renew or enrich, or to maintain the stock of this problems solutions, using the remains of previous constructions or destructions from individuals. Culturally, each pattern exists as an emergent niche in the ecosystem in which the environment becomes anticipated and ecologically encultured due to many learners activities. Patterns can appear like visible

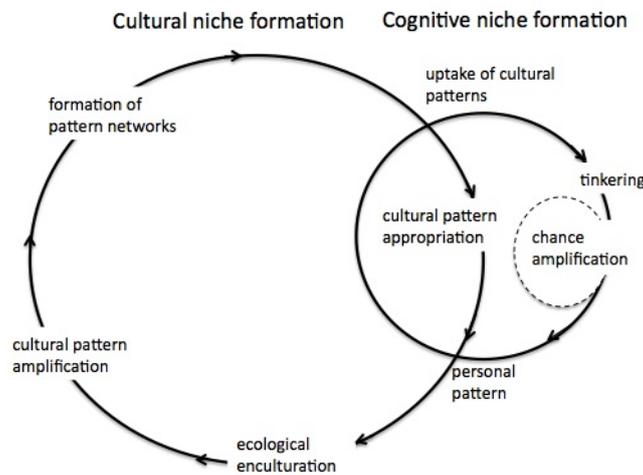
macro-structures of processes or structures: i) event sequences in distributed systems (e.g. learning paths), ii) semantic knowledge structures (e.g. tag clouds), or as iii) functional (e.g. design solutions as collective phenomena) or iv) behavioural (social network visualisations of interaction) compositions. In MOOCs, mainly the structural patterns of resources and behavioural patterns of users have been visualised with learning analytics tools that have been incorporated to the courses, while recognising processual patterns (e.g. transformative knowledge flows in the ecosystem operated by and incorporated into learning services by producers), and functional patterns (e.g. design structures of the ecosystem services, their abundance and interrelations) is not well supported with visualisations. Neither were such patterns dynamically fed back to the learners. One might anticipate that interacting with the environment having a specific learning goal, the appropriation of patterns would decrease the need to seek chances, since the ecologically encultured environment can lead you with patterns that might do the job effectively. The trivial understanding of pattern usage is, that taking a pattern it can be used as a template for repeating the pattern. However that view of pattern-replication is misleading, since there are no defined patterns one can “take” but patterns exist in an abstract way as effective niches in the encultured environment, which are evolving constantly. These niches emerge as abstract spaces and the range for the pattern niches is created as the fitness of many similar individual patterns is tested in the cultures ecosystem. Alexander et al. [29] calls such niches the pattern prototypes. The embodiment of pattern prototypes has person-dependent and culture-dependent components and variability, therefore at every juncture patterns are perceived and accommodated as part of the chance-seeking process. They are the raw material for bricolage and tinkering. Since learning is a prospective form of cognition that is projected onto and into the future, it is only known by the learner that a collectively formed pattern facilitates something and encapsules the potential of eculturation as some kind of “niche” of this culture that has sorted out some solutions. But he does not know whether any collectively defined pattern helps him in his learning. So we may claim that there can be no learners who are pattern-replicators – using patterns is always related with deviations within the pattern niche. And this pattern niche may be extended or shifted radically by chance-seeking, when totally new solutions are tinkered with as part of learning.

Patterns can be found because they are cognitively afforded partially internal and partially culture defined multi-dimensional spaces [30]. The discoverability of patterns of the culture is related with the cultural belonging as well as the EDC of individuals. The patterns exist as pattern systems, the overlapping niches in the ecosystem from which the chance-seeker may discover and tinker with. An option for finding dimensions incorporated into cultural patterns is aligning one’s attention in MOOCs with crowded places, looking for the traces left by others, or mimicking and uptaking others’ behaviours in the environment. This is mostly what is happening in current MOOCs that do not comprise sufficient

pattern visualizing methods to accumulate learner's behaviours and feedback to them. Another limitation of supporting learning from encultured environment is that the art of creating emergent visualisations that support learners in MOOCs is still not sufficiently advanced. Not much is known about how learners use such visualisations to orient or reorient their learning activities.

#### 4 Designing MOOC Ecosystems to Support Distributed Cognition

In the design approach we suggest considering MOOCs as ecosystems where producers use and also create learning services. Learning services are incorporated into distributed cognitive systems of learners as well as operate the transformative learning flows in their personal and shared distributed cognitive system. The abundance, diversity and variability of the learning services, their interconnections, aggregation and interaction in the MOOC learning ecosystem become the important design considerations that enable distributed cognition for MOOC participants. We posit that dynamically maintaining the emerging learning services in MOOCs as well as promoting distributed cognitive learning behaviors – chance seeking and pattern appropriation – may be done effectively using principles that govern natural ecosystems. Evolving MOOCs as productive distributed cognitive systems presumes promoting the productive loops of pattern appropriation, chance-seeking and ecological enculturation (see Figure 1).



**Fig. 1.** The distributed cognition – pattern-finding, chance-seeking and ecological enculturation loops

We can relate the two types of distributed cognition to cognitive and cultural niche formation. The epistemic distributed cognition comprises two loops of cognitive niche formation – the creative loop of chance-seeking uses the ecosystem unanticipatedness for chance-seeking, tinkering with chances and chance amplification and results with personal patterns as cognitive niches; the accommodating loop of pattern appropriation builds on cultural anticipatedness and results with validating and amplifying some cultural patterns. The collective distributed cognition and the formation of cultural niches as optimal collectively selected solution paths is fed by the personal patterns. Personal patterns as cognitive niches are incorporated to the cultural patterns and cultural niches of these patterns. The chance-seekers create cognitive niches that may extend or shift the cultural pattern niches evolving the ecosystem, whereas pattern appropriation activity validates cultural pattern niches and stabilizes the ecosystem.

The design approach employed in MOOC ecosystems to promote epistemic and collective distributed cognition is twofold. On the one hand the connectivist MOOCs should be built so that they facilitate the self-organisation of learning ecosystems, which promotes environmental unanticipatedness for chance-seekers. On the other hand, for promoting pattern appropriation and increasing ecological enculturation different means of learning-analytics should be used that make patterns in the shared cultural niche visible for learners.

## 5 Conclusions

In this paper we discuss what makes MOOCs ideal environment for being incorporated into distributed cognitive processes of learning. Our main contribution is to introduce learning behaviours in MOOC ecosystems from the distributed cognition point of view. We propose chance-seeking, pattern appropriation and ecological enculturation concepts to generalise some learning phenomena that MOOC learning design should target.

We assume that learning involves a forward-looking attitude. The learner as a chance-seeker engages the environment in a series of trial and error and, in so doing, benefits from the feedback and modifies the environment. Chance-seeking does not happen in a vacuum but is environmentally and culturally mediated. Chance-seeking is based on environmental unanticipatedness – the idea that the environment plays an active role in a given course of action, since unanticipated and unexpected events potentially open up the way to new knowledge or information we would not be able to acquire otherwise. Chance-seeking is defined as tinkering with events that fall out of one's control and the amplification of their potential positive significance for learning. The product of chance-seeking is the formation of one's personal cognitive niche that is not immediately available to other learners. However, as long as it leaves traces in a shared environment, it may be re-interpreted and re-enacted by others depending on their knowledge, goals, and the interaction with other cognitive niches present in the cultural niche. The result of many chance-seekers self-organised cognitive activities is ecological enculturation. Cognitive niches from learners epistemic distributed

cognition may be accumulated as emergent shared collective niches and enculture the environment ecologically. It is increasing the anticipatedness of the environment by pattern formation and pattern finding that are forms of Collective Distributed Cognition. Learning from the ecologically encultured patterns may help the learner, since one can try to replicate and or/exploit what other learners have already done, and it may be easier to achieve the learning flows determined by the culture.

The individuals' self-directed learning behaviour, personal learning environment (PLE) and – network (PLN) creation, accompanied with open publishing and sharing practices cause MOOCs to be open, dynamic, self-regulated and evolving learning ecosystems. The ecosystem architecture of MOOCs as communities of learning services that producers activate from digital components allows considering the ecosystem principles to be used for designing productive MOOCs that can promote chance-seeking and learning from ecological enculturation. The nature of interrelations between the learning ecosystem organisms – producers, digital components and digital learning services – allows the emergence of distributed cognitive systems. Our future studies are directed towards exploring the potential of utilizing ecosystem principles in designing learning ecosystems that make use of how we conceptualize learning as the distributed cognitive process.

**Acknowledgments.** This research was supported by the Estonian Science Foundation and co-funded by the European Union through Marie Curie Actions, ERMOS72.

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