

Learning Ecologies of Lifelong Learners: Development and Outcomes



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With the Name of Allah, Lord of the Worlds...

I dedicate this thesis to my eldest son, AbduAllah,

Hoping he soon grows to appreciate and embrace scholarship

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He who does not express his gratitude to those around him is not grateful to his Lord.

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Abstract

Advancements in information technologies have opened up access to learning resources that support lifelong learning. The learning ecologies paradigm has been advocated to capture the nuances of learning as afforded by these advances and across contexts. However, studies adopting this paradigm to subtleties of lifelong learning are limited. This study proposes and evaluates a detailed conceptual framework and an associated data collection methodology to explore lifelong learners' learning ecologies. The hallmark of the framework is the consideration of the multiple topical ecologies making up the overall lifelong learner's learning ecology. The thesis uses a mixed method approach to follow 24 lifelong learners, enrolled in an online course, based in Egypt, over an 8-week period, to understand the development and outcomes of their learning ecologies.

The study found that lifelong learners, while interested in a myriad of topics, activate, downscale, and hibernate topics as needed over time. Topics are relatively homogeneous in their ecological makeup, especially when compared with the overall ecologies. Moving between topics, lifelong learners showcase an ecological signature that reflects both their innate preferences and the wider context within which they live and learn.

The study's framework operationalises three outcome variables to study the effects of the variations in learning ecologies: (a) amount of learning activity, (b) progress along the individual topics studied, and (c) satisfaction with the support provided by both the topical and overall ecologies. The study found satisfaction to be very subjective and individually driven. Diversifying the learning resources has been identified as the

strategy most associated with higher levels of satisfaction. Satisfaction with the overall ecology is not associated with total amount of learning activity. And satisfaction with the respective topical ecologies is not associated with the progress along those topics. Increasing the number of resources, as opposed to diversifying their types, has been associated with both higher levels of activity and more progress. Multiple other factors have been significantly associated with level of activity and progress respectively.

DECLARATION

I declare that this thesis is a presentation of my original research work and has not previously been submitted for a degree from any other university. To the best of my knowledge, this thesis does not contain any material previously published or written by another person except where duly acknowledged in the text.

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1. Introduction

Whilst writing the first draft of the discussion chapter I had dinner with a friend, an Oxford alumnus. Catching up on each other's updates I learned he has inherited property investments and has accordingly switched to managing real estate investments as his new bread-earning job. Later in the discussion, amazed by his knowledge of the intricacies of real estate market, and immersed within the ideas of my thesis, I asked him "how have you learned about real estate?". My friends answer resonated so much with my readings, findings and original motivation to embark on this specific topic, it lent itself to this place, introducing my whole thesis,

My friend answered that several of his extended family members work in real estate, he has accordingly "mentally-appointed" a couple of them as his informal real estate mentors. Beyond those, he engages, as part of the day-to-day realities of managing his inherited property investments, with lawyers, developers and contractors, learning about real estate whilst getting the job done; on-the-job learning so to speak. He acquired a number of popular books on the subject, as well as some less popular and more research-oriented books on the subject. "The sort of books that would be on the reading list of a Masters on Real Estate Management," my friend elaborated. He also followed some YouTube channels set up by London real estate experts.

Going through a Master's Program on Real Estate Management was an "alternative strategy" recommend by another family member. Trained as a corporate lawyer and

practicing at a major law firm, this family member drafted a five-year journey for him to master property management entailing this Masters and then a couple of years working in a real estate consultancy. My friend, consulted with other family members – those informal mentors. They advised he does not need this formal approach for his purposes; managing inherited real estate properties.

My friend's journey in pursuit of advancing his knowledge on the topic of real estate exemplifies lifelong learning in action. Universities can no longer teach, or facilitate the learning of, everything needed to perform our ever-evolving and dynamic roles as adults in society. Furthermore, they do not and need not facilitate the lifelong learning needed to pursue our evolving hobbies, passions, and curiosities. Adult lifelong learning along and beyond tertiary education is, and has always been, an absolute necessity.

Typical of lifelong learning journeys, my friend's learning journey has spread over multiple contexts entailing a multiplicity of learning resources. Advancements in information technologies have opened up access, in abundance, to learning resources that support lifelong learning. Furthermore, these advancements, including mobile technologies, have blurred up the boundaries between previously discrete contextual entities. Navigating this abundance and blurred up boundaries my friend, as well as other adult lifelong learners, had to exercise agency, deciding between and upon a number of learning strategies to achieve his learning objectives. *The research informing his decisions*, and the decisions of the individuals

and organizations supporting his learning, considering the affordances and wider effects of these information technologies, *is limited* (Sangrá et al., 2019).

1.1. Rationale

A learning ecology perspective, positioning the lifelong learner at the centre of a personally curated ecology of resources, has the potential to fill this gap in the literature. A learning ecology perspective follows learning as it crosses these contextual boundaries. It captures the variety of resources supporting the learning, and considers the strategies enacted. Barron (2006), in her seminal paper *Interest and Self-sustained Learning as Catalysts of Development: A Learning Ecology Perspective*, identified five strategies enacted by learners pursuing interest based learning. Table 1 below presents those five strategies mapping them onto my friend's enacted strategies, highlighting the entailed resources.

Table 1 Mapping my friend's learning strategies to Barron's (2006) strategies

My Friend's Strategies	Barron's Strategies (Barron, 2006, p. 217)	Entailed Resources
popular books & research oriented books	"finding text-based informational sources"	Books
day-to-day realities of managing his inherited property investments	"the creation of new informal activity contexts"	lawyers, developers, contractors, tenants
YouTube videos from real estate experts.	"exploration of media"	multimedia
extended family members-mentally appointment informal real estate mentors	"the development of knowledge networks such as mentoring relationships"	Teachers/Mentors
Real Estate Management Masters and working in a real estate consultancy	"the pursuit of formal or structured learning opportunities"	Books, Multimedia, Assignment, Teachers, Peers,...etc.

Lifelong learning, like all other forms of learning, entails two types of processes; "mental processes" taking place within the learner, and "interaction processes" taking place between the learner and her material and social environments (Illeris, 2007). The material and social environments comprise (i) material resources, such as books, articles, videos and software, (ii) social resources, such as peers, family members, and tutors and mentors, and (iii) opportunities to interact with social and material resources such as classes, projects and assignments. Digital technologies have facilitated access to an abundance of social and material resources, and opportunities to interact with them.

From the point of view of the individual learner, researchers have conceptualised different configurations of social and material resources that individuals interact with as *individual learning networks* (Carvalho et al., 2015; Carvalho & Goodyear, 2014; Natriello, 2016) or *personal learning ecologies* (Barron, 2006; Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2006; Luckin, 2010). The network view has the shortcoming of negating the nodes in the network incapable of engaging in reciprocal interactions, such as books, articles and other material resources. And the ecological view has the extra merit of emphasizing the bi-directional influence relationship between the configurations, i.e. “the ecology,” and the individual learner. Explaining the power of the ecological perspective in highlighting the dynamics between the different elements making up a learning context, Zhao and Frank (2003) say:

To understand why the zebra mussel so rapidly invaded the Great Lakes ecosystem, ecologists must understand the interaction of ecological conditions, including characteristics of the invading species, characteristics of the existing species, temperatures, and other geographical characteristics. Similarly, to understand computer uses in schools [*or in our case, lifelong learning journeys*] we can no longer continue the tradition of studying discrete factors in isolation. Instead we need to become “ecologists” and provide an organic, dynamic, and complex response to this organic, dynamic, and complex phenomenon. (p. 810).

Studies of lifelong learning taking an ecological perspective are limited. Learning ecologies, broadly speaking, are “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” (González-Sanmamed et al., 2019). Compared with research on learning within formal institutions, research on learning which crosses contextual boundaries, broadly speaking, is still largely in its infancy (Ito et al., 2013; Kumpulainen & Sefton-Green, 2012; Sefton-Green, 2004,

2006, 2013; Zimmerman & Bell, 2012). In their conceptual reviews of the lifelong learning literature, Billet (2014) and Hager (2021) criticize the overemphasis on formal learning as hindering the progress of the lifelong learning research. More precisely, in a review of the learning ecology literature, having mapped the identified studies onto the level of education, Sangra et al (2019) highlighted a gap in the adult learning segment.

1.2. Aims of the Study

In this study, I take an “ego-centric” view, instantiated in an ecology, in order to develop insights into how technology-mediated lifelong learning unfolds beyond the boundaries of any one single context, enabling me to identify differences between learners’ recorded ecologies. This research defines learning ecologies as *the configuration of learning resources across contexts that a person interacts with allowing for the learning of specific topics*. The definition distinguishes between those resources a person has access to and those a person actually interacts with, identifying the latter to comprise a person’s learning ecology (Barron, 2006; Luckin, 2010). The totality of the resources abundant in a specific locality, including those technologically-mediated, distributed resources, would on the other hand comprise a regional ecology (Barron, 2006; Brown, 2000).

This study proposes and evaluates a detailed framework and an associated data collection methodology to explore the learning ecologies of lifelong learners. The hallmark of the framework is the consideration of the multiple topical ecologies

making up the overall lifelong learner's learning ecology. Each of those topical ecologies are in turn composed of social and material resources interacted with across contexts. My friend's real estate investment learning ecology is a *topical* ecology, entailing a variety of resources and crossing contextual boundaries. Considering other topics he concurrently pursued captures his *overall* ecology. Previous studies, adopting an ecological perspective, focused on single topic ecologies disregarding the other topics pursued by the studies' respective participants.

The thesis uses a mixed method approach to follow 24 lifelong learners, enrolled in an online course, based in Egypt, over an 8-week period to understand the *development* and *outcomes* of their learning ecologies.

Research Questions:

Bridging this gap in the literature on the learning ecologies of lifelong learners, and paving the way for more studies capturing the nuances of the technology-enhanced context crossing the research aims to answer the following question:

- 1- How can we systematically and scalably capture data about the learning ecologies of lifelong learners?
- 2- What can this systematic approach tell us about how lifelong learners shape their learning ecologies?
- 3- What can this systematic approach tell us about the effects of these different ecological parameters on lifelong learning?

1.3. Outline of the study

A convergent parallel mixed methods design has been chosen wherein both quantitative and qualitative data are collected at roughly the same time and then integrated in the interpretation of the overall results (Creswell & Plano Clark, 2017). The quantitative part entails mostly intensive repeated measures data collected by a diary application. The qualitative data entails fieldnotes, interview transcripts and research participants' reflections. Twenty-four adult lifelong learners were chosen as the sample group for this study. Almost all of study sample participants are parents, residing in Cairo, pursuing interest-driven lifelong learning, predominantly in Arabic language. They have all been part of an "Introduction to Education" online course designed and delivered by the researcher¹. The course is not certified by any accrediting body and has only been pursued by the participants based on interest. The topic 'Education' was one of several topics of interest pursued by almost all students. The course has been participatively observed by the researcher. And the participants used Learnapp, a mobile-based structured learning diary designed and developed by the researcher, to succinctly self-report on their daily learning interactions.

Constructing representations of learning ecologies necessitates capturing the multiple learning interactions a learner engages in, along with thick descriptions of the contextual factors describing these interactions, building an accumulative picture of the overall ecology. Capturing the multiple learning interactions, along with thick

¹ Myself

descriptions, necessitates collecting *real-time* and *retrospective* data (Conner & Lehman, 2012). Real-time data came through Learnapp and participant observation. *Retrospective* data came through follow-up interviews, a survey, and reflective essays submitted by the participants. Figure 1 below summarizes the phases of the research project and the associated data collection sources.

Learnapp data and online course fieldnotes were collected during Phase II of the study. In-depth interviews, student submissions and a name generator survey were collected during Phase III. Beyond real-time and retrospective data collection, iterative qualitative and quantitative analysis is pursued to answer the research questions.

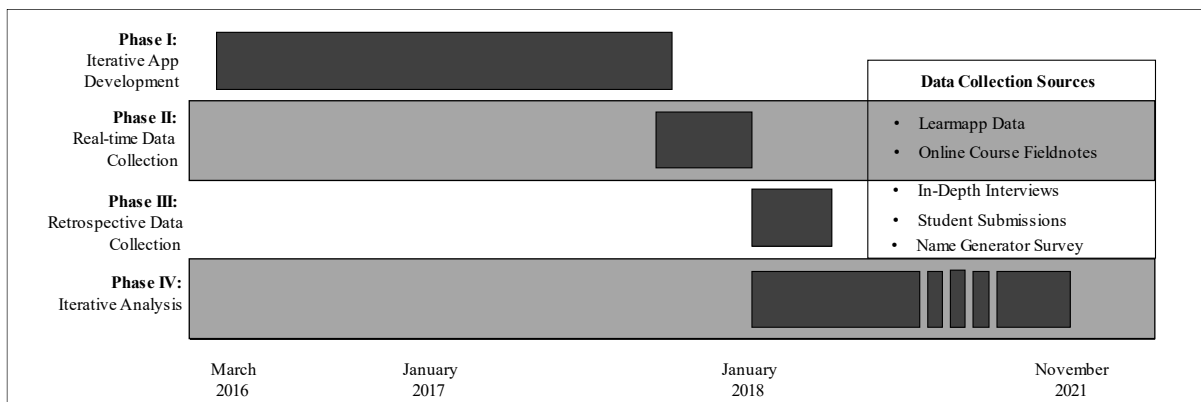


Figure 1 Timeline of Research Study

Analysis had been iterative, moving from qualitative to quantitative in multiple cycles. The transcripts, reflection statements, researcher's field notes, and application forms submitted by the participants had been the subject of early qualitative analysis answering a number of questions concerning the variations, changes, and effects of ecologies, and the exercise of learner agency. This early qualitative analysis also helped validate and re-code lots of the structured data collected through Learnapp,

preparing it for descriptive and exploratory quantitative analysis. Primary quantitative analysis aimed to quantify the variations. Further quantitative analysis was conducted to explore the relationship between the variations in the ecological parameters and the ecological outcomes. Finally, qualitative analyses was conducted to identify the factors affecting one specific ecological outcome, namely satisfaction with the support provided by the ecology.

The subjects of the above analysis are 892 learning interactions logged by the research participants, 120 topical learning ecologies, and 24 overall learning ecologies. All of the 24 research participants had in common a topical learning ecology to which the online course belonged. The online course was a common structured complex opportunity amongst all participants. Variations in the structure, form and level of support provided by this specific personal learning ecology, to which the course belongs, is of special importance explaining lots of the personal and circumstantial factors behind the variations.

1.4. Contribution of the thesis

This thesis makes four key contributions:

1. *Conceptual contribution:* The thesis proposes and evaluates a theoretically informed framework for analysing cross-setting overall personal learning ecologies of adult lifelong learners, the hallmark of which is recognizing the multiple topical ecologies making up the overall ecology. This is novel as previous frameworks are either single-setting (Eradze et al., 2015; Normak et al.,

2012; Pata, 2008, 2012), single-topic (Barron, 2004; Luckin, 2010), or not suitable for capturing the complexities associated with adult interest-driven learning (Martin et al., 2014). The framework also proposes a set of outcome variables to evaluate topical lifelong learning and its supporting ecologies.

2. *Methodological contribution*: The thesis provides new insights and understanding of how to use learning technologies (mobile and online) to provide researchers with a real-time self-reporting method by which they can capture data about the details of learners' learning journeys and learning ecologies, along with the nuances of the impact of utilising such a method on these journeys and ecologies.
3. *Development of Ecologies (Empirical)* : The thesis contributes an explanation of how adults based in Cairo co-create their learning ecologies by (1) exercising judgements around perceptions, (2) continuously managing the levels of activity across topics and (3) exhibiting some form of consistency, termed 'ecological signature', in their choices of types of resources and contextual dimensions of the learning interactions.
4. *Outcomes of Ecologies (Empirical)*: The thesis also contributes an understanding of the relationship between the variety of *ecological parameters*, capturing the configuration of resources in ecologies across topics and contexts, and the outcomes highlighted in the framework proposed in the thesis.

1.5. Structure of the Thesis

Below are detailed descriptions of the remaining chapters in this thesis:

Chapter 2, '*Conceptualizing Learning Ecologies*,' reviews the literature relevant to the study. It starts by reviewing the learning ecology perspective as adopted in the 'Education' literature broadly speaking. Then it moves on to elaborate on Bronfenbrenner's Bioecological Model of Human Development which serves as the theoretical foundation for the investigation in the thesis (Bronfenbrenner, 1979; Hayes et al., 2018). Finally, it moves on to a review of three bodies of relevant literature: lifelong learning, social network analysis and mobile-based research.

Chapter 3, '*A New Empirical Framework*,' presents the study's proposed framework. The chapter builds on, and extends, theoretical and empirical literature pioneered by Bronfenbrenner (Bronfenbrenner, 1979; Hayes et al., 2018). The extensions and enrichments draw heavily on Barron (Barron, 2004, 2006, 2010, 2014) and Luckin (Luckin, 2010) amongst others. The framework proposes three main components making learning ecologies: Topics, Resources and Contexts. The framework also distinguishes these components from intrinsic and external factors influencing those ecologies. It also proposes a set of outcomes to evaluate topical lifelong learning and its supporting ecologies.

Chapter 4, '*Methodology*,' details the overall research design, how and why the methodology had been developed. It also explains the data collection context, methods and sources, the data analysis undertaken, the ethical considerations, the role of the researcher and the study's methodological limitations. The chapter details how the research design, entailing the utilisation of Learnmapp to collect structured repeated measures data along the duration of an online course, helps answer the research question. Further illuminating the research design decisions, the chapter

presents the methodologies utilised in previous empirical learning ecology studies. It then positions the study's methodology as filling some blind spots left out by previous methodologies.

Providing data collection context, the chapter also thoroughly explains the features of the app, and lots of the technical issues associated with it. Furthermore, the chapter provides a rich description of the online course's objective, design, resources and the students' participation in it. This thick description provides the necessary background to appreciate the evidence rallied to support various claims and findings throughout the rest of the thesis.

The sources and quality of the data are also elaborated on in the chapter. Sources of data include the learning logs captured by the App, or manually recorded by some of the participants who opted out of using the App for logging their learning. They also include their statements reflecting on the logged journeys, their application forms enrolling into the online course, a name generator survey conducted post-course to triangulate the data collected through the App about social resources, and the interview transcripts.

Chapter 5, '*Describing Ecologies*,' is devoted to case studies and comparative case analysis. In this chapter, the framework, presented in Chapter 3, is used to analyse four cases studies of four of the research sample's participants. Case analyses and comparisons are used to inform and update the conceptual framework. They are also used to analyse the *development and outcomes* of the learning ecologies of lifelong learners.

Chapter 6, '*Quantifying Ecologies*,' investigates the development of ecologies across the wider sample. It sets the stage for investigating the outcomes, the subject of Chapter 7, by exploring the ecological parameters varying from one learner to another and identifying suitable metrics to capture them. The chapter frequently contrasts the data as captured by the App and as reported by the participants in their interviews, and reports on the re-coding process conducted to enable such quantitative analysis. The chapter is concluded with (1) a summary of the key metrics measuring the ecological parameters, and (2) a summary of the findings concerning the development of ecologies.

Chapter 7, '*Ecological Outcomes*,' details the relationship between the variety of ecologies, represented by variation in ecological parameters across learners, and the outcome variables. It entails analysis from both quantitative and qualitative inquiry.

Chapter 8, '*Discussion*' discusses these findings in light of the literature under six themes. The first four, grouped together under one section, address how learning ecologies of lifelong learners are *shaped*. The last two, grouped together under a second section, address the relationship between the *outcome* variables and the ecological parameters or metrics.

Chapter 9, '*Conclusion*,' summarizes the conceptual, methodological and empirical contributions of the thesis. Then it discusses the limitations of the study. A special section is devoted to reflecting on the positionality of the researcher. Directions of future research are finally suggested.

2. Literature Review

This section entails a presentation of the literature relevant to this study. The section starts with a thorough overview of the different strands of research in Education adopting a lifelong learning paradigm. The reason the review is extended to include wider educational literature, and not confined to the literature on the learning ecologies of lifelong learners, is the aforementioned scarcity of such research. The section then moves on to elaborating the theoretical framework adopted, yet extended, in this study; Bronfenbrenner's Bioecological Model of Development. Extensions to this framework, on the other hand, are the subject of the upcoming chapter, Chapter 3. The third part of the section provides an overview of the lifelong learning literature, given the subject segment of this study, namely lifelong learners. The fourth section provides an overview of social network analysis, which is relevant both methodologically and empirically. Methodologically because its analysis techniques have been adopted for analysis purposes in this study. Empirically because the insights and findings contributed by this literature of social support networks, communication patterns and information gathering are all relevant to lifelong learning.

2.1. Ecological Perspective:

Studies taking an ecological perspective have evolved from referring to one single physical environment to referring to extended ecologies, across several physical and virtual contexts, with the learner at the centre. Questions pertaining to how various resources available within a given ecology support students' learning were central from the onset of this research perspective. Similarly, questions pertaining the interaction between the constituents of ecologies, supporting students' learning, were a central as well. On the other hand, questions pertaining to factors that lead to specific configurations of resources, across the formal and informal, home, school, community and distributed contexts, do not rise until the latter publications within this ecological research perspective. The reasons for that are twofold; (1) the distinction between resources as potential supports versus actual supports does not come about until studies evolve from classroom ecologies to virtual environment ecologies; (2) and the realization that learning crosses contextual boundaries is not confronted until studies evolve from virtual environment ecologies to extended individual ecologies.

2.1.1. Physically-Bound Ecologies

Classrooms as Ecologies

Earlier studies took up one physical environment, namely the classroom, as the ecology under investigation. And although they varied in the main species under consideration and in methodology, they all emphasized student learning as the dependent variable and relationship between elements of the ecology as

independent variables. Sommer (1967) studied the effects of the physical environment of the classroom, represented by the seating arrangement, on the interactions within the classroom, and subsequently on student learning. Doyle (1977a, 1977b) interested in teacher effectiveness shifted focus to the role of the teacher within the classroom ecology, emphasizing that teacher effectiveness is not merely a function of subject-matter content mastery, but also mastery of using the subject matter within the complexities of the classroom settings. More recently, Leo van Lier (1996) and Tudor (2001) proposed and adopted an ecological approach to the study of the language learning classroom. They identified participants (teachers and students), artifacts, processes and structures as the main elements of the ecology. Participants undertake processes, interacting either with other participants or the artifacts, which they defined as materials among other physical things of significance in the classroom, within the structures, which are the organizational configurations of the classroom environment. Van Lier (1996), Tudor (2001), Sommer (1967) and Doyle (1977a, 1977b) all justify their adoption of an ecological perspective by its affordance of a framework through which interrelatedness between these elements, and the complex causality relationships could be studied. An ecological perspective, they held, necessitated research designs that would attempt to explore the complex systemic relationship between each element and all of the other elements.

Schools as Ecologies

Zhao and Frank (2003) utilised the ecological perspective, taking the school as the ecosystem, to study the factors affecting teachers' usage of technology in schools (Zhao & Frank, 2003). Their study of 19 schools within four school districts in one Midwestern state in the United States adopted an ecological perspective to move beyond the simple listing of factors contributing to the usage of technology to understanding the interaction between these factors. "Four metaphorical equivalents" were established by the authors; schools were identified as ecosystems, technology uses as living species, teachers as the keystone species, and external education innovations as invasions of exotic species (Zhao & Frank, 2003, p. 811). Their study entailed both macro-level analysis of the district, state, and national influences upon the ecosystem, and micro-level analysis of the interactions within and between different types of species.

Regional Organizational Ecology

Both of the two aforementioned adoptions of the ecological perspective have restricted their ecological lens to the formal system. In their article Knutson, Crowley, Russell, & Steiner (Knutson et al., 2011) and in a subsequent article (Russell et al., 2013) the researchers utilise an ecological perspective of learning. Contrasting their ecological perspective to that proposed by Barron they hold that

Barron's perspective is from the perspective of the individual learner, however theirs is an organizational learning ecology (Russell et al., 2013). Ecology defined by those researchers is the landscape of art learning opportunities that exist across a network of informal and formal organizations (Knutson et al., 2011, p. 311).

Although the perspective adopted in this research is more towards the individual ecology perspective, two important implications of the ecology metaphor are worth noting here. Both are identified by Knutson et al. The implications of an ecological metaphor are the strength of “diversity” and attention to “interdependence” (Knutson et al., 2011, p. 311; Russell, Knutson, & Crowley, 2013, p.262). Diversity, they hold, a measure of the strength and health of an ecosystem, implies a robust learning ecology. Also, interdependence, a reality of both biological and organizational ecosystems, implies the need for the various formal and informal organizations in the ecosystem to play to their strengths.

2.1.2. Virtual Environments as Ecologies

The internet and the information revolution pushed a second wave of research adopting the ecological perspective to distinguish between potential and actual learning resources when depicting learning ecologies. The internet did not merely enable the creation of virtual learning environments, it also provided an abundance of distributed learning resources these virtual environments could utilise (Brown, 2000). Considering the virtual learning environment as the ecology, encompassing an almost infinite number of resources, necessitated distinguishing between those

which are actually interacted with from those with which interaction potential. From another point of view, the logging capabilities of virtual learning environments also facilitated collection of specific data about what learners actually interacted with.

Among those who studied virtual learning environments as ecologies, with the learner at the centre of these ecologies, was Kai Pata and a number of collaborators (Eradze et al., 2015; Normak et al., 2012; Pata, 2008, 2012). The group's main aim was to model the trajectory of learners across the virtual learning ecologies. Their model is comprised of a learning space that entails all the "persons, competences, tools, methods, services and artifacts involved in the learning process" along with their qualities and characteristics (Normak et al., 2012, p.264). Within this learning space resides a learning niche representing a subset of this space possibly related to a community of learners but also entailing only subset of all the other factors. A learner, occupying a position within this space does not perceive the whole space, rather merely a perspective of this space. The position is not only relative to other people in the learning space but also relative to a learning objective or outcome. Moving towards this outcome takes place through steps along a path (Normak et al., 2012). Pata and her collaborators (Normak et al., 2012; Pata, 2008) analysed two different case studies using this model, distinguishing, among other things, between actual and potential resource interactions. They did that through their learning space, learning niche and learning perspective constructs.

Building upon this distinction, they emphasize two theoretical points, stemming from the ecological perspective on which their model has been built. First, the resultant learning, they emphasize, "depend[s] on the nature of the 'architecture' of the

components of the system (e. g. connectivity, clustering), the characteristics of species, and their diversity and distribution, and interactions between them (such as commensalism)” (Eradze et al., 2015, p.2). Second, the learning niche is constructed through a “feedback loop to and from the environment that enables species to be adaptive to the environment and the environment to change as a result of species” (Eradze et al., 2015, p.2). These two theoretical propositions will recur throughout this literature review, and the research proposed aims to empirically explore them.

2.1.3. Extended Technology-Mediated Learner Ecologies

Luckin (Luckin, 2008, 2009, 2010) started off studying virtual learning environments, however, her ecological model came to fruition as her conception of the learning environments extended across multiple contexts. Luckin traces the roots of her *learner centric ecology of resource* framework to two early projects, ECOLAB I and II, in which she was trying to explore how software could offer assistance to children within their Zone of Proximal Development (ZPD) as theorized by Vygotsky, among other scholars (Luckin, 2009). Developing the theoretical framework, she distinguished between the term Zone of Available Assistance (ZAA), highlighting potential resources available for learning, and the Zone of Potential Assistance (ZPA) highlighting those resources filtered through to the learner for potential assistance. Luckin developed her model further through three other research projects. In her (2010) monograph she elaborates the difference between ZAA and ZPA through an example. A child wants to work on a mathematics problem and needed some assistance: resources in the ZAA include videos viewed at school

earlier in the day, drills and exercises in the activity book, help from parents, teachers, and peers amongst other resources. The child might not know of the availability of some of these resources, was it not for the attention drawn to it by one other resources. The ZPA is “constructed through a negotiation between the child and their More Able Partners” (Luckin, 2010, p.28). More Able Partners are those resources that offer scaffolding to the learner, and they themselves are part of the child’s ZPA. Luckin (2010) points out to the concept of distributed scaffolding which extends the More Able Partners concept beyond the confinements of specific resources, to configurations of resources across multiple contexts. Figure 2 below shows the relationship between ZAA, ZPA and ZPD.

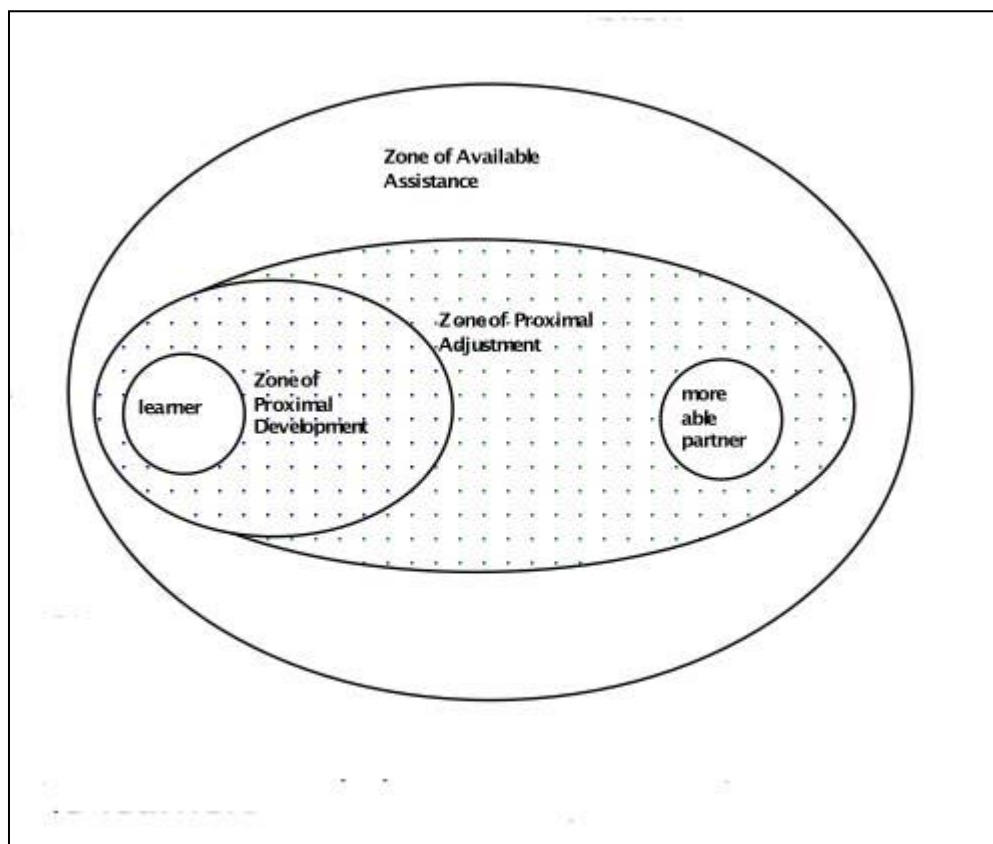


Figure 2 Zone of Collaboration (Luckin, 2010)

The final model (Luckin, 2008, 2009, 2010), labelled the *learner-centric ecology of resources*, includes the learner at the centre of the model. Around the learner are all the potential learning resources and elements, forming the ZAA. Luckin (2010) divides these learning resources into three categories; first is the “stuff that is to be learnt” or the “knowledge and skills” as she labels it, second is the “tools and people,” which primarily constitutes the More Able Partner, and third is the “environment” in which the learner, More Able Partners, Resources, and tools, all exist (p. 91). ZPA, is formed through (a) an interactive relationship between these categories, (b) filters identified for each category, and (c) an interactive relationship between these filters. The filters are curricula, administration and organization, for knowledge, resources, and environments respectively (Luckin, 2010). Figure 3 below shows the three categories, the three filters and the relationships between them. Finally, the ZDP entails those developmentally appropriate interactions, with resources, in which the learner actually engages (Luckin, 2010).

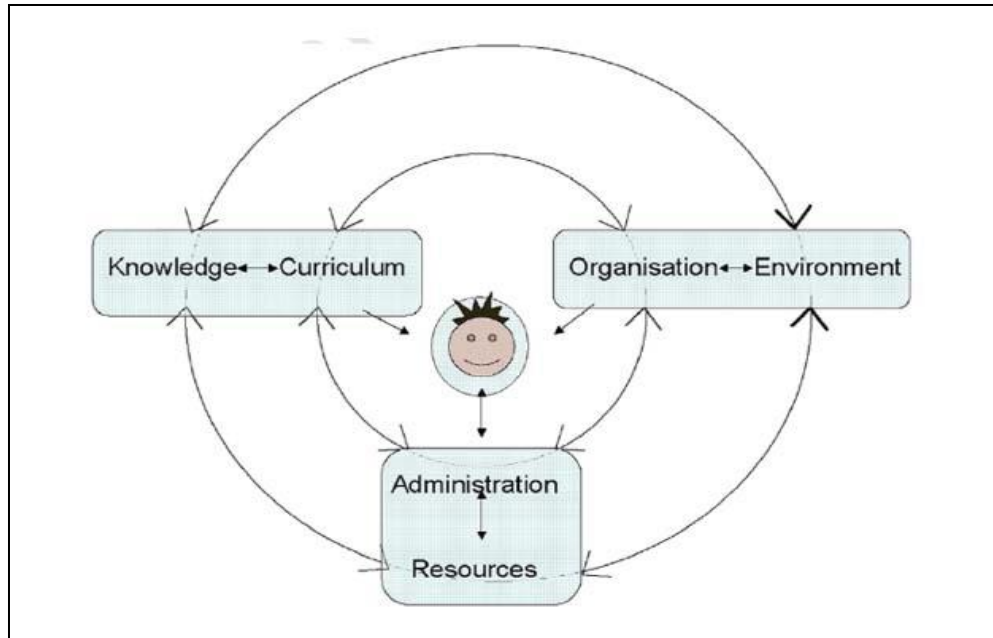


Figure 3 The Elements of An Ecology (Luckin, 2010)

Both Pata (Laanpere et al., 2014; Pata, 2012) and Luckin (Luckin, 2008, 2010) have the betterment of designs of technology for learning as the main aim of their modelling efforts. Both models emphasized the dependence of the student learning on the complex relationships between the various components of the ecologies. Furthermore, both have distinguished between (1) resources available, (2) resources perceived as appropriate for potential interaction and (3) resources actually interacted with. Including this level, of resources *perceived* as appropriate for interaction, emphasizes the role of the learner in conceiving and creating his actualized ecology of learning. The models were proposed to guide the design of learning environments and have been inspired by studies of, and applied to, specific learning environments. As mentioned earlier, both models are ecological models, focusing on interactions with resources and include the elements other than the learner in the ecology, such as his peers, mentors and materials, and the

relationship between these elements and one another. Both add an emphasis on the learning objectives. The models did differ in that one included only the resources within the virtual learning environment (Eradze et al., 2015; Normak et al., 2012; Pata, 2008), and the other included resources crossing multiple contexts, albeit mediated by the virtual learning environment (Luckin, 2008, 2009, 2010).

2.1.4. Extended Learning Ecologies

Barron, similar to Luckin, developed a framework to study learning that crosses contextual boundaries. Barron (2004) initially proposed her learning ecology framework, extended upon Bronfenbrenner's (Bronfenbrenner & Morris, 2006) Bioecological Model of Human Development, responding to survey results, in a study of learning about technology, indicating such learning was "distributed over several settings and across many types of resources" (Barron, 2006b, p.195). Similar to Luckin, Barron, has "the person as the organizing central node in the system, and thus differs from more traditional uses of the term, which usually refer to a single physical environment" (Barron, 2004). Her questions in the first two publications, utilising this ecological framework revolved around understanding which learning experiences, or proximal processes, advancing technological fluency do male and female students engage in, and the effects of their engagement therein (Barron, 2004; Barron et al., 2007).

Working with an equity agenda, intending to expand access to learning opportunities to minority and less privileged students, Barron sought to find ways to increase the breadth and depth of learning experiences. Her seminal paper propagating her ecological perspective, published in the *Human Development Journal*, relatively generalized the question towards interest-driven learning asking “why, how, and when adolescents create learning opportunities for themselves?” focusing on the learner’s agency in creating his/her learning ecology (Barron, 2006b, p.197). She later focused on the role of parents in creating and/or supporting learning opportunities (Barron et al., 2009). She examined the role of context, schools and access to tools – in school, at home and in other settings – on the breadth and depth of learning experiences and opportunities (Barron, Walter, et al., 2010). Barron also inquired into the role, and nature, of generative experiences which trigger and generate further opportunities and experiences (Barron et al., 2014). In a recent publication, reporting on findings from a study in Science education, rather than digital literacy which has been the domain of all of her former studies, Barron broadened, whilst generalizing, her inquiry to identifying ways that learners’ “interests are supported and extended across everyday, informal, and formal boundaries” (Crowley et al., 2015, p.1).

Barron’s extensive research body (Barron et al., 2014; Barron, Martin, & Roberts, 2007; Barron et al., 2009; Barron et al., 2010; Barron, 2004, 2006; Crowley et al., 2015) mostly explores the nature of learning activities and the factors that influence them. Barron’s (2004, 2006) initial motivation for the study of learning activities was

expanding access to quality ones, i.e. rich learning ecologies, for minorities and those less privileged. Barron was specifically focused on bridging the digital divide offering such children, and students, digital creation experience, which comprise quality learning activities in the field of technological fluency (Barron, 2004, 2006; Barron et al., 2014). As such, inquiring about learning activities, Barron drew upon Bronfenbrenner's ecological perspective, along with a strong sociocultural perspective, to develop a specific conceptual framework (Barron, 2004, 2006). Barron has adopted Bronfenbrenner's theory into a framework to study the learning ecologies through which children develop technological fluency. As shown in Figure 4 below, the central circle represents the topic intended for learning, technological fluency development, and is broken down into multiple sub-topics. The squares connected to the central circle represent home, school, work, distributed resources, peers and community as six specific settings for the development of technological fluency. Within each setting she specified a number of potential activities, resources and projects with which the child could interact.

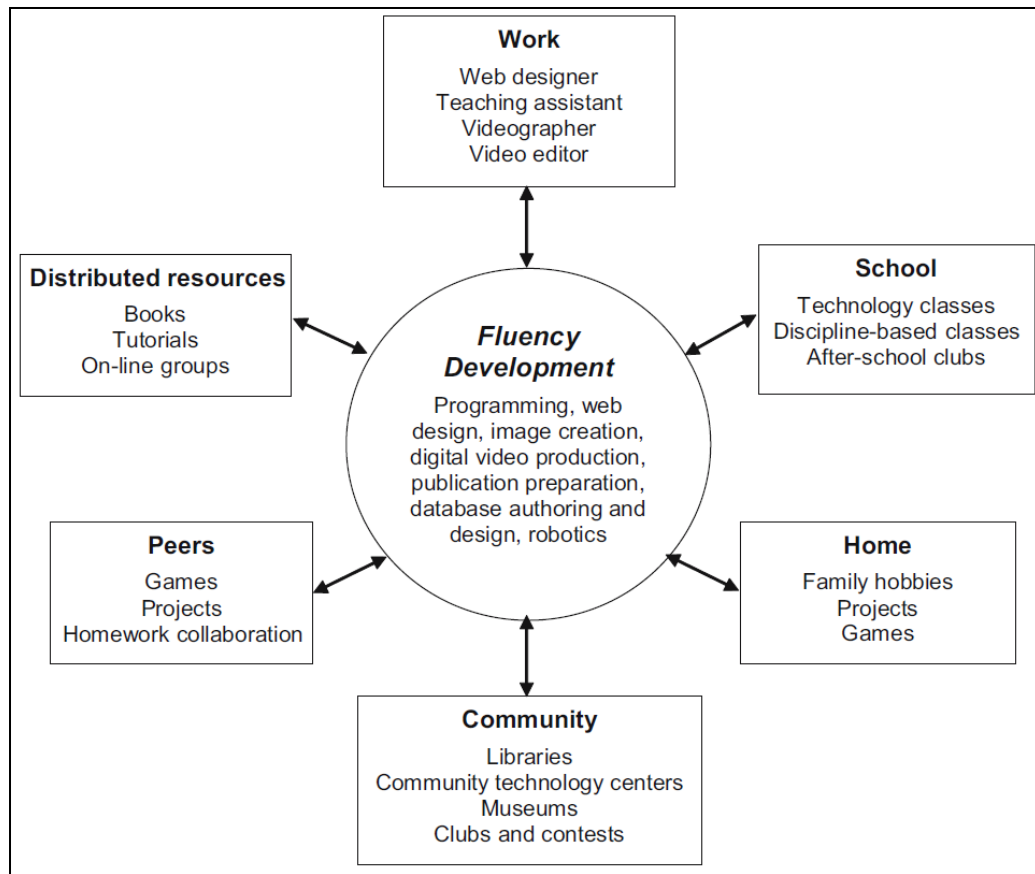


Figure 4 Contexts for Fluency Development (Barron, 2006)

2.1.5. Review of Learning Ecology Literature

This research draws upon the conceptualizations, insights and findings aggregating through the aforementioned research literature, as well as the lifelong learning and social networks research literatures reviewed towards the end of this chapter.

Although none of the work reviewed focused on lifelong learning, building an empirical framework to conceptualize and capture data about those learning ecologies draws most heavily on Luckin's and Barron's work. Although not precisely obvious from the diagrams and their respective narratives, Barron's model does

concur with Luckin's model over the three main components; topics, resources and contexts. These three components make up the bedrock of the framework proposed in this study, as presented in the following chapter.

In their recent review of the learning ecology literature, Sangra and his collaborators (Sangrá et al., 2019) highlight the variance of definitions given to learning ecologies. Ontological definitions captured through their study include "resources for learning", "sets of elements", "learning environments", "network/s for learning" and "an expanded system". The two main competing ontological definitions observed in the literature are those of "contexts of learning" and "environment". Concurring with both Luckin and Barron, as previously mentioned, the authors bring together contexts, relationships and resources, defining learning ecologies as: "the sum of contexts where the learner self-directs her activity, cultivating relationships and using, producing and sharing resources" (p. 1621). Interesting, however, context is the starting point in the Luckin's definition, defining a "learning context as the learner-centric ecology of resource" (Luckin, 2008).

Beyond the framework proposal, this study has interventionist aims. The study lays foundations for interventions in the lifelong learning segment by putting its proposed framework in action understanding how these varieties of configurations, in the learning ecologies of lifelong learners, come to take the shape they do, and more importantly uncover some of the outcomes of these variations. Describing the literature in terms of methodologies and research applications Sangra et al note: "while the observational approaches exploring and describing LE [learning ecologies] prevail, the more "designerly" ways of research are almost non-exist" (p.

1631). Methodologically, interventionist and experimental methodologies have been rarely utilised. And in terms of research applications “developing educational interventions and assisting in their implementation” has been rarely intended.

Barron’s and Luckin’s frameworks and empirical work are amongst the few to concur with the objectives of this study. Barron’s framework has been designed to support enriching learning ecologies more broadly, by providing access to, amongst many other things, what Barron calls generative activities and resources, which in themselves provide further access to other resources. It has been applied to action supporting the learning of digital literacy (Barron et al., 2014), which is a relatively informal topic, and later applied to science education (Crowley et al., 2015). Luckin’s framework has been developed to support the design of technologies and/or activities that bridge the formal/informal divide by understanding the learners’ ecologies. It has been put to action in understanding and designing for language learning (Underwood et al., 2012), again an informal topic, and interestingly towards the adult learning segment.

Figure 5 below (Sangrá et al., 2019) shows the underlying theories used in the learning ecology literature along various education levels. The aforementioned scarcity in studies in the lifelong (adult) learning segment is clear in this figure. Disregarding the educational level, social constructivism is the most adopted underlying theoretical paradigm. Bronfenbrenner’s approach, “developmental ecologies,” the theoretical framework adopted, and extended in this study, has been much less adopted, and never in the adult learning segment.

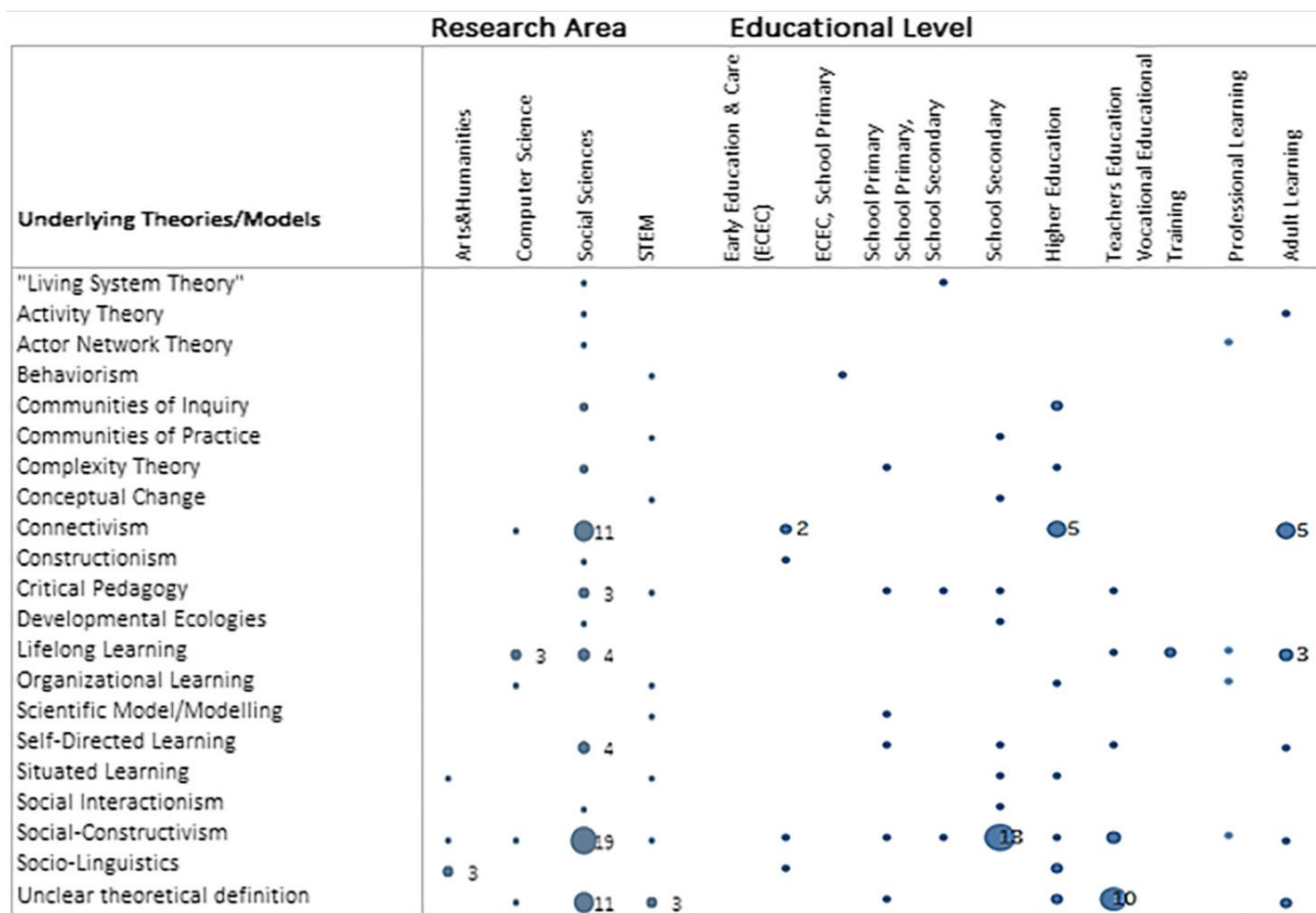


Figure 5 Underlying theories used in the learning ecology literature along the various education level

(Sangrá et al., 2019, p. 1629)

This research builds on and extends Luckin's and Barron's work, while adopting and extending Bronfenbrenner's Bioecological model of human development. In the following section, I will elaborate upon both Bronfenbrenner's theoretical model, after first justifying its adoption.

2.2. Theoretical Framework

Similar to Luckin, and many other researchers in the learning ecology field, Barron draws upon the sociocultural perspective. Unlike Luckin, however, her ecological

model builds heavily upon the ecological approach propagated by Bronfenbrenner (1979). She also draws upon Vygotsky (1978) Cole (1996) and Rogoff (2003) among others in their attention to dynamic tools such as language and other representation systems as mediators of developmental activities. Precisely, with reference to her model explained above, they've been drawn upon to detail the resources and opportunities component of the learning ecologies.

Bronfenbrenner's model has been proposed to study learning and development ecologies, rather than the wider sociocultural nature of development studied by Vygotsky, Cole, and Rogoff. Furthermore, his model, having been nurtured by its conceiver for more than three decades, offers a relatively structured framework for analysing the learning resources, their contexts, and interactions taking place in these contexts over time, thus facilitating the exploration and study of configurations and patterns of engagement with resources. Bronfenbrenner has been influenced by the soviet school and Vygotsky immensely as self-confessed in his wide spanning literature (Bronfenbrenner, 1976, 1979; Rosa & Tudge, 2013). To an extent, Bronfenbrenner's model is an extension, adoption, or merger between a social-constructivist perspective and an ecological perspective.

Another theoretical learning ecology model which has been inspirational to many researchers is Jackson's (2013, 2016) learning ecology model (González-Sanmamed et al., 2019; Sangrá et al., 2019). Jackson (2013, 2016) draws heavily upon Bronfenbrenner in his work extending and modifying it. His work, however, is mostly conceptual and has not been sufficiently applied empirically (González-

Sanmamed et al., 2019; Sangrá et al., 2019). As such, this study chooses to build on and extend Bronfenbrenner's model.

In the sections below Bronfenbrenner's model is explained at length, starting with an overview of the model, then moving on to a detailing of its four constituent elements.

2.2.1. Overview of the “Bioecological Model of Human Development”

Labels, given by Bronfenbrenner to his model, have changed through the thirty years of its evolution, and lots of details were added, but the essence remained the same.

Bronfenbrenner labelled his theory “ecological model of human development” (1979), “ecological systems theory” (1989) and “bioecological model of human development” (Bronfenbrenner & Morris, 2006), among other names. Through this evolution Bronfenbrenner uses the following words to define it:

The ecology of human development involves the scientific study of the progressive, mutual accommodation between an active, growing human being and the changing properties of the immediate settings in which the developing person lives, as this process is affected by relations between these settings, and by the larger contexts within which the settings are embedded (1979, p.21; 1989)

The theory was proposed to inform the design of research projects aiming to answer, among other questions, two of three questions at the heart of this research endeavour: (1) How do the relations between settings affect learning and development? And (2) how does the human being affect these settings.

Bronfenbrenner, arguably the pioneer introducing the ecological approach/perspective into the field of education, identifies Lewin and Vygotsky as the greatest influences on his theory (Bronfenbrenner, 1976, 1979; Rosa & Tudge, 2013). Bronfenbrenner first introduced his model to a child development scholarly

audience (1974), then eventually two years later to an educational research audience (1976). In both cases, echoing Lewin's, he had expressed concern about the ecological validity of the conclusions drawn by development and education research from laboratory experiments as the motivation for his model.

Bronfenbrenner held that:

Whether and how people learn in educational settings is a function of sets of forces, or systems, at two levels:

- a. The first comprises the relations between the characteristics of learners and the surroundings in which they live out their lives (e.g., home, school, peer group, work place, neighbourhood, community).
- b. The second encompasses the relations and interconnections that exist between these environments (1976, p.5).

The ecological model of human development, as it stands in its final forms, proposes four influences on the development of the human; processes, personal characteristics, context and time (Bronfenbrenner & Morris, 2006). The interaction between these four components being the fifth influence on development and learning.

2.2.2. Processes

Processes, termed proximal processes in the model, are “enduring forms of interaction in the immediate environment...between an active evolving biopsychological human organism and the persons, objects, and symbols in its immediate environment” (U. Bronfenbrenner & Morris, 2007, p.797). Proximal processes are the main driver of learning and development. They come in a wide range of forms, however, always entail an interaction, between the developing person and the resources available within the multiple contexts in which she

participates. These resources according to Bronfenbrenner may well be social resources, i.e. other persons, or objects and symbols, such as books, articles, and paintings. Objects and symbols, however, have been much less attended to in his writings (Rosa & Tudge, 2013), which is one of the limitations of the theoretical framework.

Bronfenbrenner referring to Vygotsky while talking about proximal processes, hence explaining the element of 'proximity' in the term:

Such processes serve to mobilize and sustain the developing organism's attention, instigate reaching slightly beyond current boundaries (Vygotsky's [1978] "zone of proximal development"), detect subtle relationships, and accumulate and refine both declarative and metaknowledge (Chi & Ceci, 1987) (Bronfenbrenner & Ceci, 1994).

2.2.3. Personal Characteristics

Personal characteristics, are those dispositions, orientations or skills that influence initiating or engaging with the proximal processes. Bronfenbrenner distinguished between three types of personal characteristics; force, resource and demand characteristics (Bronfenbrenner & Morris, 2006). Force characteristics are those which ignite proximal processes, and they include curiosity, initiative and openness. Resource characteristics are those which do not ignite, but rather shape the engagement within, proximal processes, and they include knowledge, skill and experience. Demand characteristics, rather than igniting action on behalf of the developing person, invite or inhibit others to interact with the developing person and include attractiveness and hyperactivity, which contrasts with passivity.

Bronfenbrenner also notes that negative force, resource and demand characteristics

can impede development by preventing or disrupting proximal processes.

Bronfenbrenner also includes in these personal characteristics age, gender and ethnicity as important factors affecting learning and development (Bronfenbrenner & Morris, 2006). The richness in classification of personal characteristics creates much needed structure for exploring the second question central to the proposed research, namely how does the person affect the structure of his learning ecology.

2.2.4. Context

Context, is the environment to which the developing person belongs, and is divided into four hierarchical systems (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2006). The first is the microsystem within which the proximal processes/interactions take place with objects, people or symbols. The *microsystem* includes the context of home, school, peers' homes, community centre and mosque/church, amongst other contexts. The *mesosystem* comes next entailing the interactions between these various microlevel contexts. Thus, the mesosystem highlights the relationships between people, objects and symbols across these various contexts. The *exosystem* is a system to which the developing person does not belong but is influenced by. Finally, the *macrosystem* has as its hallmark the overarching ideology or belief system. Figure 6 below shows the nested relationship between these four levels of context, around the individual, as theorized by Bronfenbrenner.

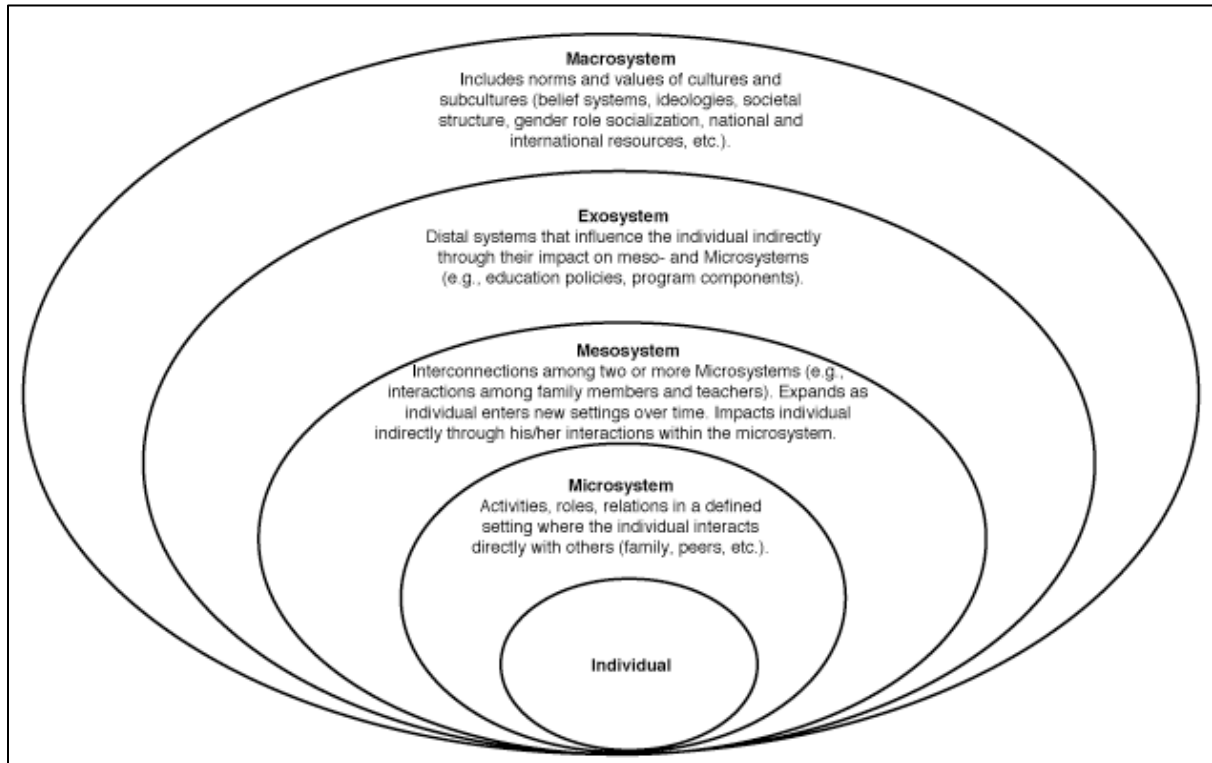


Figure 6 Levels of Context (Bronfenbrenner, 1979)

Explaining these hierarchical systems may best be done by an example. Although both the exosystem and macrosystem are beyond the scope of the intended study, the example will cover the former, distinguishing it from the mesosystem. Consider a child interested in learning a certain scientific concept. She might talk with her father, at home, about this scientific concept advancing her domain knowledge. She might undertake an experiment furthering her understanding of this scientific concept with her teacher, in the school. Both proximal processes are taking place in the *microsystem*, which is the immediate affecting the development of the child.

Consider then the father talking with the teacher about the child's interest in this specific concept. This interaction is not between the child and any other person, as such it is not a proximal process, and however, it is still an interaction very likely to

affect subsequent proximal processes involving the father and the teacher. This interaction is an interaction taking place in what Bronfenbrenner terms the *mesosystem* context. Consider next the father of the child having some problems in his workplace. These problems are merely processes or interactions not involving the child, rather, they are also interactions with other persons, objects or symbols with which the child has never interacted, nonetheless they might have a profound effect on the proximal processes involving the child's father. These contexts beyond the scope of the child are the *exosystem* level of a child context.

2.2.5. Time

Time comes in finally as the fourth component of the model (Bronfenbrenner & Morris, 2007, p.797). Similar to context, time has multiple levels; microtime, mesotime, and macrotime. Microtime captures the individual proximal processes, mesotime captures their frequency and macrotime captures the wider historical time context around the developing person.

Bronfenbrenner succinctly explains the relationship between the elements:

“Proposition II: The form, power, content, and direction of the proximal processes effecting the development vary systematically as a joint function of the characteristics of the developing person, the environment – both immediate and more remote – in which the processes are taking place, [and] the nature of the developmental outcomes under consideration. (Bronfenbrenner & Morris, 2007, p. 798).

Proximal processes could be between the person, and social or material resources.

The interaction between the person and another specific person could take several forms. Proximal processes could entail a dyadic relationship between the person and the resource, within the microsystem, and they could entail a triadic relationship

between the person and two resources, within the mesosystem. Specific proximal processes could be frequent or infrequent. “To be effective,” Bronfenbrenner emphasizes, proximal processes “must take place on a fairly regular basis and over an extended period of time” (Bronfenbrenner & Morris, 2007, p.797). Furthermore, proximal processes could be initiated by the learner or the social/material resource with which the interaction is taking place.

According to Bronfenbrenner’s “Proposition II,” the form, frequency, direction, and even content of proximal processes, which collectively constitute to what this research labels as *patterns of engagement* with resources in the learning ecology, are affected by (1) the characteristics of the developing person, (2) the characteristics of the environment, and (3) the nature of the developmental outcomes under consideration, herein referred to as *learning topic*.

2.3. Lifelong Learning

This section presented an overview of the lifelong learning literature. This overview summarises the definition and scope of lifelong learning as discussed in the literature, specifying the scope espoused in this study. Feeding into the framework proposed in this study, the second and third sub-sections summarise the processes and outcomes of lifelong learning respectively. A final sub-section discusses the digital nature of lifelong learning.

2.3.1. Scope and Purposes

Lifelong learning has come to prominence in two waves; the first of which spurred in the 1970s was triggered by a UNISECO report (Faure, 1972), the second spurred in

the 1990s continues to the current day (Smith, 2001). The first wave was marked by a confusion of terms, between lifelong learning, lifelong education, and recurrent education, whilst the second, fixated on the suffix 'learning', debated the scope and purpose (Hager, 2021).

The scope based on definitions ranges temporally from a focus on post-compulsory, or post-tertiary, to continuous learning over one's lifespan, "from birth to death" to quote some proponents (Kaplan, 2016). The scope based on the type of learning also ranges from a focus on the formal, beyond compulsory and tertiary, or informal supplementing, or complementing the formal, to an all-encompassing entailing formal, informal and non-formal (Friesen & Anderson, 2004; Kaplan, 2016).

Accordingly its responsibility has been confused between governments, organizations, and individuals (Billett, 2014; Hager, 2021). The purposes along its first wave of prominence were social and humanistic. On the other hand, the second wave revolved around the economic imperative. Although, international organizations were at the centre of both waves, the economic imperative formed a part, but was not in the centre of the first wave (Hager, 2021). Within these confusions and debates some reverted to using the term "life-long, life-wide and life-deep learning" (Banks et al., 2007).

Working within the lifelong learning segment this research espouses a definition that is temporally confined, to adults, yet inclusive to all types of learning and all purposes. The research, and public policy, obsession with the 'controllable' formal has also been stifling the personal and societal impact of lifelong learning (Hager, 2021). "The concept that has implications not only for individuals and their work but

equally for the increasingly challenging task of creating a society that is democratic, fair, and caring” (Fleming, 2021). Promoting a wider purpose agenda, within for lifelong learning, Billet (2014) says:

These purposes include learning to communicate with others, engaging with social partners and developing the capacities to engage in socially valued activities, one of which is work. It also includes continuing to develop those capacities across working life including learning how to engage in new occupational activities across working life. Yet, in addition, there is also learning associated with roles that emerge across our lives, to be a son or daughter, brother, sister, twin, partner, parent and carer for parents, etc. (Billett, 2014).

2.3.2. Processes

The learner is at the centre of the lifelong learning process. She is in charge of her learning. Although she is supported by a plethora of others, as shall be explained, inhabiting the post-compulsory segment, learner agency gets a necessary role in shaping the intensity and direction of the processes of learning, to name the least (Billett, 2014; Jarvis, 2004). Heutagogy, tightly aligned with adult lifelong learning, has been distinguished from andragogy in putting the learner at the centre of their learning, giving permanence to self-direction, self-determination and self-regulation (Hase & Kenyon, 2000, 2007; Snowden & Halsall, 2016). “Students define what they will learn and how they will learn and assess their learning” (Blaschke, 2021).

The second element central in the processes of lifelong learning are others. Beyond the acquisition and transfer metaphors implying an “other” imparting knowledge, lifelong learning thrives on the support accessed and engaged with by the lifelong learner (Hager, 2021). Summarizing the kind of support provided by others Billet says:

Much of this guidance and support arises from engaging with other people either directly (Rogoff 1995) or, perhaps more commonly, indirectly through observing them, listening to them (Billett 2001), undertaking the activities they suggest (Pelissier 1991), reading what they have written or engaging with what they have produced. (Billett, 2014)

The third element, which must not be neglected, is organizations (Billett, 2014). Formal education organizations like universities still provide part of the learning taken up by lifelong learners. Informal learning organizations like training centres and online course providers also offer learning taken up by lifelong learners. Workplaces, community and religious organizations also offer learning taken up by lifelong learners.

2.3.3. Digitally-Mediated Nature

Considering these purposes and processes, digital technologies are having a profound impact on lifelong learning. Koper and Tattersall (2004) summarize the barriers to lifelong learning presented by Longworth (2003) under five categories; mental, financial, access, learning design, and information barriers. They hold that mobile and digital technologies can help overcome the last three barriers (Koper & Tattersall, 2004). It could be argued by lowering the cost of delivery per unit, digital technologies are helping address the financial barrier too.

Mental barriers entail those barriers in the mindset of the adult learning, such as low self-esteem and self-efficacy. The lifelong learner's lack of funding to engage in lifelong learning falls under the *financial barriers*. *Access barriers* entail the lifelong learners' inability to access a lifelong learning provision, by an institution, due to its

geographical distance. *Learning design barriers* entail the mismatch between lifelong learners' needs, learning styles or circumstances and the provision of lifelong learning. *Information barriers* entail the lack of sufficient information concerning the available lifelong learning provisions. Addressing the access barriers, advances in information and communication technologies have allowed lifelong learning education programs and courses to be delivered to learners' laptops and other digital mobile devices from the comforts of their home (Koper & Tattersall, 2004). And premise-less delivery has allowed more and more organizations to set up delivering and provisioning various forms of lifelong learning suited to the various needs, styles and circumstances. Digital technologies allowed "long-tail learning" which entails "shifting away from a focus on a relatively small number of 'hits' at the head of the demand curve toward a huge number of niches in the tail" (Collins et al., 2009, p.22). Considering this (1) relative abundance of provision, (2) to expansive market, (3) through an information centric medium (namely the internet), lifelong learning providers have taken up lots of measures to make sure enough information is provided about their offerings (Koper & Tattersall, 2004). Arguably also, continuously advancing digital technologies have lowered the cost of lifelong learning provision, addressing the financial barrier.

Beyond organized provision, the internet facilitated access to the resources (both social and material) that fuel lifelong learning for personal and professional purposes. In essence, the internet comprises interlinked hypertext resources accessed through browsers, "these resources may include any or all of these: texts, images, audios, videos and multimedia, hyperlinked to each other" (Panda, 2009,

p.251). Beyond these material resources, these mechanism allowed the development of the social networking website. These “new social software systems... provide access beyond the classroom to communities of practitioners and experts within one’s context and across the globe” (Panda, 2009, p.252).

Taken together, these developments have led to digital being an integral dimension in lifelong learning for personal and professional purposes. Pew centre has published a report in 2016 highlighting the increasing digitality of lifelong learning (Horrigan, 2016). “Digital technology plays a notable role... but place-based learning remains vital to many” (Horrigan, 2016, p. 1). Accessing smart phones, and other digital connected devices, for information seeking and learning purposes has been widely reported by adult and lifelong learners (Tabuenca et al., 2013). In fact, “adults with tech-access tools are more likely to be lifelong learners and rely on the internet to pursue knowledge” (Horrigan, 2016, p. 31). Unfortunately though, adults from lower income and education levels were reported to benefit less from these technological advances and affordances (Horrigan, 2016).

2.3.4. Outcomes

Outcomes are important elements in framework proposed to discuss phenomena. Unfortunately, the lifelong learning literature highlights challenges assessing the outcomes of lifelong. “Learning resulting from daily life activities related to work, family... is not structured in terms of learning objectives, learning time or learning support and typically does not lead to certification” (Livingstone, 2001, p.3).

“Another dilemma in assessing informal learning is the ubiquitous, self-directed nature of that learning,” says Watkins et al (2014). “How does one capture and codify something so omnipresent, individually tailored, emergent and so invisibly conducted? And should one do so?” (Watkins et al., 2014). Following on the challenging nature in its outcomes, on the affective front, lifelong learning has been reported in some studies to positively influence wellbeing and in other studies to negatively influence it (Field, 2009).

2.4. Social Network Analysis

Social network analysis, is a branch of network science, both of which are lines of inquiry into the complex relationship between various units in a certain system (Robins, 2015, p.4). It poses itself as an important body of research considering the alternative metaphor espoused by many educational researchers broadly (Carvalho et al., 2015; Carvalho & Goodyear, 2014; Natriello, 2016), and lifelong learning researches in specific (Goodyear, 2021; Koper & Tattersall, 2004), to study learning as interactions with social and material resources, across contextual boundaries. In embracing the social networks literature, this study does not confine itself to the aforementioned personal *learning* networks literature, owing to the insights and explanations brought about through the wider methodological and empirical contributions in this body of literature.

In social network analysis “social structure and social influence are measured and mapped, making what is powerful, but so often hidden from view, observable to scientists” (Hanish & Rodkin, 2007, p.1). In social network analysis various actors and elements are depicted as nodes, and relationships between them are depicted

as lines, or edges between those nodes. A large set of statistical techniques have been created to analyse the composition and structure of such networks. Of relevance to this study are measures of density, which measure the number of actual relationships between actors in a network as a percentage of the potential number of relationships (Robins, 2015). Considering the learning ecology as a network, and the various resources therein as the nodes of the network, measures of network density could prove as a valuable measure of the interdependence of an ecology, as opposed to fragmentation, which is another way to describe the configuration of the network.

Social network research can be broadly divided into two segments mapping onto the two segments identified for learning ecology research: whole networks and personal networks (also referred to as ego networks) (Crossley et al., 2015; Robins, 2015). In the first type, which would include the regional, or physically bound ecologies mentioned in 2.1.1, centrality, density, reciprocity and homophily, among other measures are studied. The aim is to understand the connections between nodes, the attributes of the connected nodes and the central nodes, amongst other whole network based phenomena (Crossley et al., 2015; Robins, 2015). In the second type, under which personal learning networks fall, the research is confined to a central ego, its alters, and their attributes. Measures, as per Table 2 below (adopted from Crossley et al., 2015) capture the total number of alters, the variety of the ties with those alters and the proportion of alters according to the attributes, amongst other measures.

Table 2 Summary of Ego-net measures (Crossley et al., 2015)

Measure	Description	Ego-alter ties	Alter-alter ties	Attributes
Tie central tendency	Total number or mean of ties	X		
Tie dispersion	Distribution or variation of ties	X		
Alter central tendency	Proportion in each attribute category or mean	X		X
Alter dispersion	Distribution of alters across attribute categories or variation	X		X
Ego-alter similarity	Similarity of ego attributes to alter attributes	X		X
Structural shape	Measures determined by the pattern of alter-alter ties	X	X	

Lots of studies on personal networking are relevant to this study. Social support studies have been using social network analysis techniques to understand social support networks for a number of decades now (Walker et al., 1993). Social support networks are considered as ego-networks depicting the relationships of one ego, or person, as opposed to whole-networks depicting the relationships of one locality or context (Walker et al., 1993). Typologies of various personal social support networks, or personal communities, have been thus created. They utilise various measures such as network density measures, briefly introduced above, network size, percentage of kinship and frequency of contact, amongst a host of other measures (Wellman & Potter, 1999). Typologies of learning ecologies could be similarly created, paving the way for posing and answering a number of questions concerning the configuration of resources within learning ecologies and patterns of engagement with those resources.

Also relevant to this line of work, on learning ecologies of lifelong learners, are communication patterns upkeeping social ties (Aledavood et al., 2015; Hogan, 2009; Saramäki et al., 2014). Studies on information and advice seeking in networks are relevant as well. They capture a significant number of contributions in the social network literature (see for example: Aral & Van Alstyne, 2011).

It is worth noting here that Barron (2014) mentions in a recent paper the importance of employing social network analysis techniques to analyse the evolution of learning ecologies through exposure to rich ecological interventions. This research utilises social network analysis techniques to analyse the data collected through a mobile-based application. Considering each learner ecology as an ego-network, various statistical attributes of these networks will be calculated and linked with the perception of ecology's support, learning topic and, potentially, various learner actions.

2.5. Summary

This review has shown that the empirical literature adopting a learning ecology perspective takes the learning ecologies to denote different things: (1) physically-bound environments (such as classrooms, schools and informal learning organizations in a specific region), (2) virtual environment (such as MOOCs and other online learning platforms, (3) learner-centric, technology-mediated context crossing ecologies, and (4) wider personal learning ecologies (irrespective of being managed, mediated or orchestrated by a central technological platform.

Considering the scarcity of research on learning ecologies of lifelong learners, all the aforementioned research, with all its different foci, informs and illuminates this study. Breadth, depth, diversity and, broadly speaking, composition have been noted through the various reviewed works as important parameters of variation between ecologies.

From amongst these works, Luckin's "Ecology of Resources" and Barron's "Learning Ecologies" frameworks and associated bodies of empirical and design-based research have been noted as particularly relevant and important. In fact, this research, as shall be elaborated in the upcoming chapter, builds on those frameworks, adopting, whilst also extending, Bronfenbrenner's Bioecological model of human development. Bronfenbrenner's bioecological model of human development, adopted and extended in this study, is to an extent a merger between the Soviet social-constructivist school and the ecological perspective.

Bronfenbrenner's ecologies are comprised of the personal characteristics of the central learner, the processes by which the learning takes place, the contexts that the learning inhabit and the time over which it spreads.

The framework proposed, in the upcoming chapter, is intended for exploring the learning ecologies of lifelong learners. In this chapter, a brief overview of the lifelong learning literature showed that lifelong learning is pursued for personal, social and professional purposes. In alignment with the learning ecology literature surveyed, the literature portrayed a lifelong learner at the centre of the learning process which

takes place through interactions with others, with organizations and institutions organizing some of the lifelong learner's learning. Digital technologies have been shown to be an integral and inseparable part of the lifelong learning process for many. Considering the nature and scope of lifelong learning, lifelong learning outcomes were shown to be particularly troublesome in defining and capturing.

The final section of this chapter entails an overview of the social network analysis literature. Various elements of social network analysis were shown to be of empirical and methodological value for this study.

3. A New Empirical Framework

Utilising a mobile-based application to construct representations of lifelong learner ecologies through sampling their micro-interactional processes² necessitates developing a new framework that fits this purpose. Making data input intuitive necessitates simplifying some of the dimensions in Barron's and Luckin's frameworks, and detailing other dimensions. The following sections presents the framework proposed to suit these purposes. The first section serves as an overview specifying and justifying various components of the framework. The sections following that elaborate on the details of those components: topics, resources, contexts and outcomes.

3.1. Components of a Learning Ecology

González-Sanmamed, Muñoz-Carril, and Santos-Caamaño published a study in British Journal of Education Technology's special issue on learning ecologies attempting to identify the key components of learning ecologies. They utilised the Delphi method engaging a total of 12 different academics from Canada, Spain and the United Kingdom over three rounds with the final objective being the identification of key components of learning ecologies. They used levels of agreement amongst the panellists' to aggregate a list of 29 elements, then reduced them into seven key components running along the life course of the learner. Figure 7 below shows these seven components grouped into two dimensions: the intrinsic dimension and the experiential dimension. The former pertaining mostly to learning dispositions entails

² or what Bronfenbrenner calls proximal processes

the learner's conceptions, motivations and expectations. The latter pertaining to learning processes entails relationships, resources, actions and context.

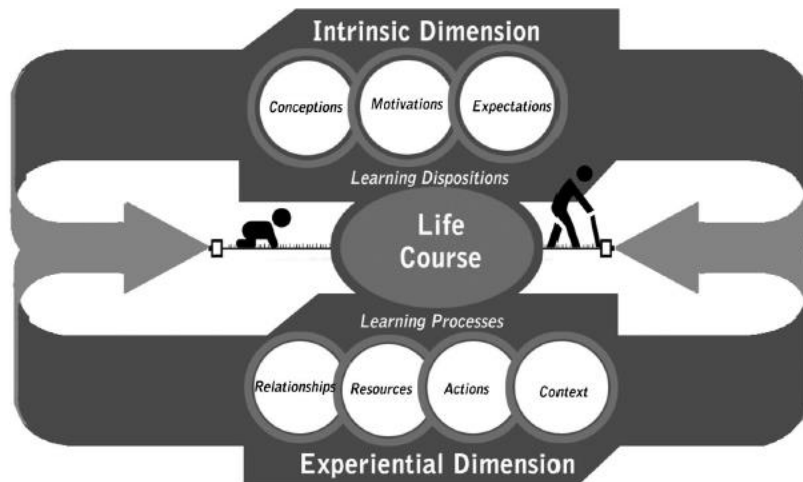


Figure 7 González-Sammamed et al Component of Learning Ecologies (2019)

Topics

Topics, an agreed upon element between Barron and Luckin, does not reveal itself easily in the model by Gozales-Sanmamed et al. Barron placed it at the centre of her model, and Luckin abstracted it into knowledge and skills. Exploring lifelong ecologies calls for exploration of multiple topics simultaneously. Going back to Figure 7 it could be argued that those intrinsic elements collectively represent the topic pursued, albeit from the perspective of the learner. Motivation, expectations and conceptions are all arguably topic-centric; a learner's motivation is towards certain topics, and lies on a strong to weak continuum. Similarly their sense of self-efficacy, among the many 'conceptions' is topic related. However, the rest of the experiential elements are also topic centric, or largely so. Teaching *relationships*, books, videos and articles, as examples of *resources*, and courses and workshops,

as examples of actions and activities, are all topic-specific. *Context* is the only one of these elements that would usually serve more than one topic, and even so, many contexts, such as ateliers and hands-on workshops, as also topic-specific. For the purposes of exploring the learning ecologies of lifelong learners, explicating ‘topics’ as an ecology component is drastic.

Resources and Contexts

Beyond topics, Barron, Luckin and the panel of experts, agree that relationships, resources and contexts are components of learning ecologies. Barron calls the former two ‘social’ and ‘material’ resources, respectively. Luckin calls them ‘people’ and ‘tools’. And these shall be elaborated in subsection 3.2 below, titled by merging both categories under the title ‘Resources’. Barron calls context ‘settings’ and Luckin calls it ‘environment’ and this component shall be elaborated on in subsection 3.4 titled ‘Contexts’.

Actions (or Opportunities)

Actions are tricky. They are the blood line of learning ecologies. They connect the learner to the resources. González-Sanmamed et al include under this element both singular activities and strategies, the aggregate of singular activities (González-Sanmamed et al., 2019). Speaking of strategies, they refer to Barron’s five strategies mentioned in the introductory chapter of this thesis. Barron’s strategies have been analysed there as interactions with resources. Activities in their singular form are not an element of the ecology, rather, the tie connecting the ego to the alters, to use network terms, or the ‘interaction’ connecting the central organism to the ecological

resources, to use ecological terms. An ecology does not exist without activities, or interactions, however, they are not components of the ecology.

Activities, or interactions, successive and intentional indeed constitute a strategy. A strategy might be an agentic decision taken by the learner or structured as such by a person or entity external to the learner. As an exercise of agency, they seem closer to the intrinsic factor examined below. As structured by a person or entity external to the learner they form what can be called 'opportunities' discussed in section **Error! Reference source not found.** A prime example of such opportunities, structuring a sequence of interactions, are courses.

Intrinsic (and) Extrinsic factors

Barron does not include the intrinsic dimension in her learning ecology model, presented in section 2.1.4. Luckin on the other hand does include this intrinsic dimension, as learner resources (Luckin, 2010). In fact, Luckin expands the range of these intrinsic factors. Learner resources, or the intrinsic dimension, according to Luckin (2010) include not only learning dispositions, but also problem-solving and social skills necessary to manage the resources and their external environment (or contexts). In addition to those dispositions included in the Figure 7, Luckin also includes a relatively wide element which is the learner's prior knowledge on the subject, in that it also influences topical choices.

In agreement with Luckin this study holds that learning and non-learning dispositions along with conceptions, motivations, expectations, and prior knowledge, all these are

extremely important factors influencing a lifelong learner's ecology. Furthermore, they must be taken into consideration while designing technology to enhance this learner's learning experience. They are also extremely important factors to take into account when exploring the development and outcome of ecologies. Nonetheless, they are not elements of the learning ecologies. Bronfenbrenner's had not included personal characteristics in the earlier versions of his model, not before he added 'bio' to 'ecological model of human development'. Indeed, the distinction between an element in his model being a component of ecologies (as opposed to being a factor affecting it) had not been clear. This study agrees with Barron in not including internal factors, as components, and keeping them as factors or influences.

Speaking of factors and influences, external factors and influences must also be brought into the wider equation. A large portion of Barron's work has been studying the impact of external influences, such as parents having a tech job, on the learning ecologies and learning outcomes of her subjects (Barron, 2004). Similarly Luckin has included a variety of external influences affecting the accessed resources and contexts, such as household rules, demands and distractors (Luckin, 2010).

The extended learning ecology model

Figure 8 below brings together the aforementioned components. The blue rectangle denotes a learner's learning ecology. It is composed of topics, resources interacted with in pursuit of those topics, contexts hosting those interactions, and opportunities structuring those interactions across contexts and with resources. The learner

(intrinsic factors) and her environment (external factors) influence this learning ecology.

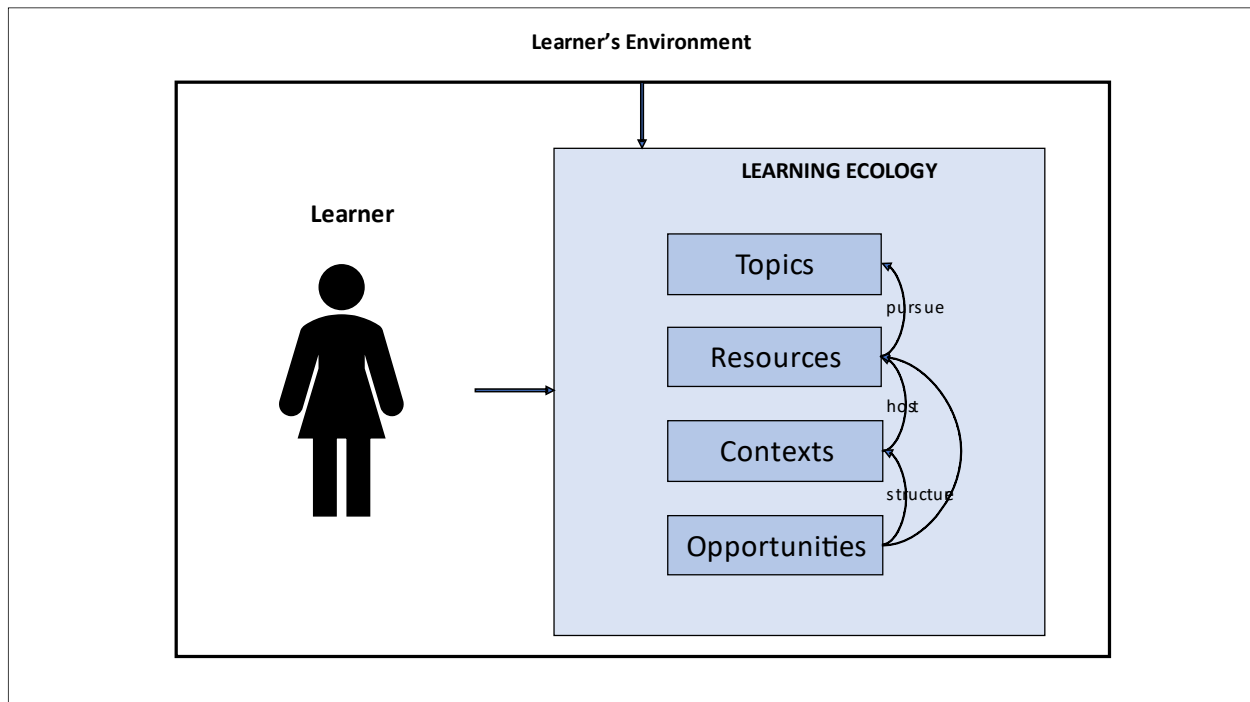


Figure 8 Proposed Components of Learning Ecologies of Lifelong Learners

3.2. Topics

Explicating topics, special attention must be paid to its multiplicity. An overall ecology is made up of multiple topical ecologies, each entailed their unique set of social and material resources. As an example, a lifelong learning might be concurrently learning Japanese language, taking driving lessons, and learning Python programming. He will be utilising different resources in pursuit of mastery along each of the three topics. Speaking of his learning ecology, we can speak of his Japanese topical ecology, entailing the resources dedicated to this topic, his driving topical ecology, entailing the resources dedicated to this topic, and the Python

programming topical ecology as such. We can also speak of their overall learning ecology, entailing all the three topics, and all their associated learning resources.

Both Barron and Luckin have conceptualized ecologies for singular topics at a time.

As was mentioned in section 2.3.1, the purposes of lifelong learning are numerous, serving work, life and leisure needs and purposes. A lifelong learner might very well be changing jobs whilst getting married, or handling new job responsibilities whilst picking up a new hobby. Understanding the development of the learning ecologies of lifelong learners necessitates mapping the resources and contexts associated with each of these topics, the choices taken by the learner pursuing these topics, and the impact these topics have on each other. Unearthing the outcomes of learning ecologies (those supporting learners and pushing them along their topics of needs and interest) also necessitates capturing the multiplicity of the topics pursued and its impact on those outcomes.

Beyond noting the multiplicity of topics, and their associated ecologies of resources across contexts, it is important to denote some of the attributes of these topics aiding the explorations on the development of ecologies and the outcomes thereof. In section 3.1 multiple intrinsic factors have been identified as topic-specific and intrinsic factors have been noted as influencing the shape of learning ecologies and the outcomes thereof. As such the proposed empirical framework must note the current level of mastery of a topic of interest, capturing ‘broadly’ the prior knowledge identified by Luckin as an important factor. Furthermore, it must cover the target level of mastery, which partially captures motivation towards the topic and, more importantly, the extent of the objective. The framework must also capture the driver

behind pursuing different topics. All cases of empirically similar topics (in terms of initial levels of mastery, target levels of mastery, or motivation) can be grouped together and analysed for the shapes of their respective ecologies and their outcomes.

3.3. Resources

To understand how learning ecologies vary from one person to another and the effects of these variations a framework has to differentiate between various types of resources. As mentioned previously, Bronfenbrenner has not extensively discussed the variety of potential learning resources. Bronfenbrenner was more interested in proximal processes, than in the resources comprising the reciprocal side of the proximal processes. He sufficed by identifying that the resources may well be persons, or objects and symbols. In the ecological sciences there is a distinction between resources and organisms; organisms, by analogy would map into social resources, and resources, would potentially map into material, or distributed resources (Begon, 2006).

In both Barron and Luckin's frameworks there are points in which they aggregate both categories into 'resources' broadly speaking and there are cases in which they separate them. In her earliest accounts Barron mentions distributed resources, as opposed to social resources, and includes both books and online materials in this category. Later (2006) she distinguishes between social, ideational, material and identity resources. And in another recent paper (Crowley et al., 2015) mentions social, cognitive, cultural and material resources. No distinctive definitions nor

examples were provided to these two extensive classification systems. Barron, however, furthered her research on one social resource, namely parents, and called for further research on other social resources such as mentors, peers and siblings (Barron et al., 2009). Luckin aggregates 'resource' under the singular title of 'people and tools', and then she goes on dividing them (Luckin, 2010). In one reference, she divides them into human, physical and digital resources. In another reference, she divides them into people, artefacts, and technologies. González-Sanmamed et al include under resources, material and technological tools, social and relational resources, ideational resources, and identity resources. This study adopts a primary classification of resources into social and material, following Bronfenbrenner's model, Barron's early classification and Luckin's primary classification model, as in the title 'people and tools'.

The study positions 'digital' as an attribute of the context, or a dimension thereof, rather than an attribute of the resource. 'Digital' is the mode of accessing the resource rather than an attribute denoting its nature. A tutor, or supervisor, could be interacted with face-to-face in a classroom or office, or digitally, in an email or through synchronous online lectures.

Ideational and identity resources, as González-Sanmamed et al would concur, overlap with the aforementioned intrinsic components. They explain ideational resources as those resources 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" (González-Sanmamed et al., 2019 adopted from Cote & Levine, 2014). Identity

resources on the other hand “refer to the ideas about oneself and one's relationship to and place in the practice and the world, as well as ideas about what is valued or good.” (Nasir & Cooks, J., 2017). Identity resources are straightforward. They are not the subject of the learning interaction, as such they should not be considered resource in this framework. Ideational resources on the other hand are tricky. In reflection, for example, which is one type of learning activity, material and/or social resources might be called upon for inspiration or referencing. And if not, ideas, concepts or memories extracted from previous interactions with social or material resources are called upon. These ideas, concepts and memories called upon are the subject of interactions in these individual reflection (learning) activities. As such, these activities could be framed also as interactions, however, with “ideational” resources. Ideas have not been included in the framework for two reasons. First, the research from its onset has focused learning as “interaction processes” with the socio-material environment (Illeris, 2007). Another, yet secondary reason, is the difficulty of identifying and capturing these “ideational” resources in a structured mobile-based diary, the data collection tool used in this research.

Beyond the classification into ‘material’ and ‘social,’ for the purposes of this research a secondary classification system is necessary. The research attempts to identify specific ecological configurations, or patterns of proximal processes within ecologies. And it attempts to do that through sample quantitative surveying conducted repetitively through a mobile-based application. The secondary classification system proposed, in the initial stages of this research would further

classify social resources into managers, peers, teachers, family and others. It would classify material resources into books, articles, other written content, audio/video media, software and other. Producing stuff usually includes a host of material resources such as pen/pencil and paper/notebook, or laptop, tablet or mobile phone. In addition to this a material resource (in text form or other) is being emergently produced. This lead to the introduction of another category in this study called 'assignments'. These categories have been revised in light of the findings, in Chapter 6.

3.4. Contexts

In the proposed framework resources are accessed through contexts. This context could be described through the dimensions of location, time, and digitality. The framework specifies courses, and other structured opportunities, as another dimension of context too. This definition of context is somewhat different to that espoused by other researchers, such as Jackson (2016) and Bronfenbrenner (Bronfenbrenner & Morris, 2006). Jackson (2016) holds that contexts “provide meaning for our provide meaning for our thinking, including our imaginings, our doings and our learning that emerges from our doings” (p.45). Elaborating his conception of context, he speaks of education and non-education contexts (Jackson, 2013). He distinguishes between contexts, spaces and time as separate elements on an ecology. Bronfenbrenner also distinguishes between contexts and time (Bronfenbrenner & Morris, 2006). Luckin, on the other hand, identifies space and time as attributes of context (Luckin, 2010).

Location

Speaking of 'space' or the location of learning, and as mentioned earlier, part of Barron's extension to Bronfenbrenner's model, was the identification of six specific 'settings' (home, work, school, community, peers, and distributed resource) relevant to adolescents' development of technological fluency (Barron, 2004). In her latter research (Barron et al., 2014) 'settings' were reduced to four: home, school, after school and community. Barron replaced "work" with "after-school," which is relatively more sensible considering children's and adolescent's learning ecologies. In her earlier model Barron includes distributed resources and peers as settings, or contexts, of development. Peers, are clearly not a context, however, she has included them as access to computers, in many instances takes place in a peer's house. As such Barron seems to have included them into community. Distributed resources are similarly resources, not contexts, accessed digitally, and thus have been removed from the classification.

Digitality

It is important to note that, in both her earlier and later versions of the framework, Barron never included the internet as a context although lots of resources are accessed through the internet. The reason is that the internet itself is accessed from home, work, school, in-transit, or any other setting. Including it would create a nested relationship. The internet, or more precisely "digital," is better suited as a description to the interaction with the resources, than the 'setting' or 'location' of the interaction, or the resources.

Time

A third dimension of the context, proposed in this framework, housing an interaction should be time. Just as the physical environment has spaces for learning, time has slots for learning. A learning interaction takes place in specific day of the week and a specific hour of the day. A specific topic's learning ecology could very well be conceived as mostly taking place in specific day(s) of the week, specific time(s) of the day, or a blend of both. The ecology would be extending over these slots temporally, just as it spreads over specific spaces locationally.

Structured Opportunities

Sometimes the learning of a topic takes place within what Barron called 'opportunities'. Barron's (2006) presentation of opportunities implies their being as opposed to 'resources', i.e. a learner learns through engagement with a resource or engagement in an opportunity. She gives courses and creative projects as examples of opportunities (Barron, 2006). Courses, creative projects, and bundles thereof (such as longer programs and degrees) are in essence opportunities to interact with a group of specific resources, furthering specific topic(s). They bring together instructor(s), peers interested in the same topic, curated multimedia and text resources, or a mix thereof. Structured opportunities are another layer in the description of context, under which interactions might or might not take place. Structured opportunities, such as courses, provide overall contextual structure for

the participants' interactions by necessitating or motivating specific locations, time slots, and modes of interaction (e.g. digital vs offline).

It is important to note that although the empirical research, described and reported upon henceforth, has captured the structured opportunities, through its qualitative data collection dimension, it has been deemed out of scope.

3.5. Outcomes

The framework proposed to further the research, beyond this thesis, on the learning ecologies of lifelong learners creating and evaluating interventions has to include outcome measures. On another level, this thesis has taken outcomes of the varying 'shapes' of the learning ecologies of lifelong learners as one of the subjects of its research questions. Three variables are proposed in this framework: progress in level of mastery of topic, level of activity, and satisfaction with the support provided by the ecology. Only the former, from amongst the three, is a learning outcome, measuring the outcome of the process of learning. The latter two are ecological outcomes, measuring outcomes of the ecologies constructed by the learners to support their learning.

As mentioned earlier, Barron has maintained an interventionist agenda throughout most of her learning ecology research. As such, most of her research capturing learning outcomes had been vital. Focused on singular and specific topics Barron mostly measured specific achievement outcomes. She has augmented that, in many

cases, by measuring the depth and breadth of experience, or the take-up of the afforded learning opportunities, as outcomes measured for ecologies. Learning achievement outcomes are difficult to create when the research is not topically bound, as in the case of lifelong learning. However, the take-up of learning opportunities, or in simpler terms, the level of learning activity, is in fact very suitable for the time-crunched adult learner struggling to engage in the necessary learning interactions.

The other measures proposed are much more subjective. After describing the different roles adults perform in their everyday lives necessitating lifelong learning, Billet says “both the processes of and outcomes of this [lifelong] learning are deemed by individuals themselves or others as being either effective or less than effective for these roles” (Billett, 2014). “This personal appraisal” he emphasizes, “is particularly the case for learning that is personally transformative” (Billett, 2014). Billet differentiates between appraising the process and appraising the outcome. Personally appraising the outcome is proposed here, in this framework, to take place by appraising the level of mastery of a specific topic towards the end of a specific period, in comparison to the initial level of mastery noted earlier as one of the attributes of each topic. Personally appraising the process, or more importantly and of relevance to this study, the learning ecology could be captured through a satisfaction score with the level of support provided by that ecology.

4. Methodology

The research outlined above employs a relatively innovative methodology to further our understanding of the learning ecologies of lifelong learners. Given the exploratory nature of the project, proposing and evaluating a framework and an associated data collection approach, a mixed methods approach has been adopted. The hallmark of the innovative methodology is the utilisation of a mobile-based learning diary application to collect data about learners' sample learning instances. *Learmapp*, the mobile-based diary application, had been used by research participants to log their learning along an 8-week *online course* designed and facilitated by the researcher as a participant observer. Added to the loggings on the mobile application, participants' application forms submitted to enrol into the course, their various submitted assignments and the researcher's field notes are all sources of data used to answer the research questions. Furthermore, follow-up interviews had been conducted with all of the 24 research participants providing precision, narrative and context to their data logged into the app. Finally, a name generator survey was filled out by the research participants after the course, and its data was validated in the interviews.

The mobile-based application was developed through an iterative pilot study, comprising the first phase of the research project. A second phase entailed the online course experience, that has been logged by the participants and participatively observed by the researcher. A third phase followed the online course with preliminary descriptive quantitative analysis of the individual data of participants

and in-depth interviews with them. The fourth and final phase entails an iterative analysis going in cycles between quantitative and qualitative analysis.

The sections below provide details about the overall research design, how and why the methodology had evolved the way it did. They also explain the data collection context, methods and sources, data analysis undertaken, ethical considerations and methodological limitations.

4.1. The research design

The subject matter of this research, namely personal learning ecologies, and the target research questions all call for a mixed methods approach. As shall be elaborated upon, in subsection 4.1.3 concerning methods of previous studies, almost all previous research on personal learning ecologies has adopted mixed methods approaches. As mentioned in the introduction, learning ecologies are defined as the configurations of learning resources across contexts that a person interacts with allowing for the learning of specific topics. This configuration is the sum of the interactions of an individual with learning resources across the spatial-temporal dimensions. Constructing a representation of a learning ecology necessitates *capturing* the multiple learning interactions a learner engages in, along with *thick descriptions* of the contextual factors describing these interactions, building an accumulative picture of the overall ecology. Quantitative data collection methods facilitate capturing the interactions, and qualitative data collection methods enrich their descriptions. Quantitative data analysis methods allow for validating a

framework describing the learning ecologies of lifelong learners which captures the elements that do vary from one person to another. And qualitative data analysis methods allow for exploring the structural and agentic reasons behind this variation and its effects.

Event-Contingent Recording (ECR) is a specific design from within the genre of methods for studying daily life. It is used in collecting intensive repeated measures in naturalistic settings (IRM-NS) making it a good candidate to the systematic collection of interactions' data (Mehl & Conner, 2012). *Learmapp*, a mobile-based learning diary application, has been custom-built by the researcher for event-contingent recording. Learmapp had been designed to allow participants to succinctly self-report their learning interactions data along with specific descriptors defined by the conceptual framework extended for this study. Structured data collected by the App, building up to construct a representation of the research participants' learning ecologies, allows analysing the variances between learning ecologies across lifelong learners and over time.

Qualitative data collection and analysis methods were deemed necessary to complement quantitative data collection and analysis. The research questions move beyond describing the reality of learning ecologies of lifelong learners with all their varieties, to uncovering the reasons behind this variation, rendering answers difficult for quantitative methodologies alone. And even understanding reality with all its nuances is difficult quantitatively considering the conceptual framework used for analysis has been purposefully extended for the specific research questions, and the data collection tool had been custom-built.

The research design described in this section has been specifically designed to answer the research questions identified in the introduction of this thesis, building on the framework, presented in Chapter 3, purposefully extended to answer these questions. The research has been designed to complement empirical findings uncovered by previous studies, hence has evolved from the methodologies they utilised.

The first two subsections below detail the various design decisions associated with the quantitative and qualitative dimensions of the research design respectively. A final subsection follows to explain the methods utilised in previous studies and how they influenced the research design.

4.1.1. Quantitative Design

Methods for the study of daily life rarely collect exhaustive data encompassing all instances of the phenomenon, behaviour, or experience under investigation. Among the various types of data which could be collected through intensive longitudinal methods, only passively collected data, which require no logging by the participant, can be collected exhaustively (Conner & Lehman, 2012). And even with such data, the sheer volume, collected over an extended period, necessitates – in most cases – sampling. Learning interactions, according to the definition of this study, entailing both online and offline experiences, could not possibly be passively collected. Learning interactions within an online learning platform, such as Massive Open Online Courses (MOOCs), could indeed be passively collected as the learner conducts his/her learning online. And even in such online learning platforms not all the associated learning interactions are captured; a discussion, for example,

between a learner and his/her colleague on any other online platform will not be recorded. This study is vitally concerned with both online and offline learning interactions, building up an understanding of the totality of individuals' learning ecologies. The study also adopts a very wide perspective on what's considered a learning interaction. As such active recording, or manual logging, is a necessity, and accordingly a sampling protocol is required too.

Sampling Protocol

From within the range of sampling protocols, and associated research designs, under the methods for the study of daily life, this study specifically adopts an event-contingent recording (ECR) data collection protocol. In ECR protocols "data recording is completed subsequent to the occurrence of a specified event" (Moskowitz & Sadikaj, 2012). The precise experiences under investigation, i.e. learning interactions, would best be identified as an event as they entail "discernible beginning and end" and data collected about interactions "should represent the whole event" (Moskowitz & Sadikaj, 2012). Other sampling protocols are not suitable for this research study. Two famous protocols are fixed-time, also called interval-contingent requesting the recording of the data relevant to specific points of the day, and variable-time, also called signal-contingent requesting the recording of the data relevant to random points of the day (Conner & Lehman, 2012; Moskowitz & Sadikaj, 2012). Both protocols are not suitable for events that "may not occur if one is sampled at fixed or intermittent times during the day" (Conner & Lehman, 2012). Learning interactions, as proven through a pilot of the described study, may not

occur altogether on specific days, and time-based sampling might necessitate an extensively long period of data collection to provide enough details to construct an individual's learning ecology. It must be noted that it is not necessary that the recording be done immediately after the event has been concluded. Rather, the fact that it is related to an event simply implies "in close temporal proximity to the event of interest" (Schwarz, 2012).

Duration of sampling

The duration of sampling for this study had been 8 weeks. Building on the pilot study, 25 learning interactions has been deemed as threshold around which a representation of the learning ecology could be clearly constructed. Considering an average recording rate of one learning interaction every two days, also informed by the pilot study, around 8 weeks of data recording have been decided. Such a duration is quite typical in ECR studies in which the event is less frequent, however, sustaining the motivation and engagement of research participants along the duration of the study is reported as a challenge (Conner & Lehman, 2012). This challenge has been largely tackled by the fact that the research participants had been logging their learning interactions as part of an online course, titled "Introduction to Education Studies," facilitated by the researcher.

Hardware Choice

Mobile technologies are already heavily influencing the field of social research. Miller (2012) identifies four types of social/psychological studies utilising mobile

technologies; First, studies utilising large data sets of call logs and locations provided by telecom providers; second, small sample collecting rich data via limited-capability mobile devices such as personal digital assistants (PDA); third, similar studies utilising researcher provided smartphone devices entailing a researcher-designed mobile application; and fourth, larger scale studies distributing such researcher-designed mobile applications to users' actual smartphone devices. Miller provides examples for research under each of the above four types.

Within the social research realm, ubiquitous mobile technologies have been initially used in experience sampling, one variant of intensive longitudinal methods for the study of daily life. Experience Sampling Method (ESM) "is a means for collecting information about both the context and content of the daily life of individuals" (Hektner et al., 2007). Traditionally, experience sampling has been conducted by beepers and paper and pencil diaries, with beepers nudging the research participants to log entries into their diaries as per the researcher's instructions. Utilising mobile technologies, ESM evolved to using PDAs, then researcher provided pre-programmed smartphones, and finally mobile apps distributable through mobile application stores such as Apple's App Store and Google's Play Store (Pejovic et al., 2015).

There are several benefits from distributing apps to user devices through the application stores. First, using current participants' devices minimizes the overheads on both researchers, having to provide devices for participants, and participants, having to use more than one device (Pejovic et al, 2015). Second, applications are released on application stores, accessible to a very large number of people,

increasing study scales and facilitating study repeatability (Pejovic et al, 2015).

Third, the multitude of sensors available on mobile devices could be utilised to gather contextual data about the research participant or at least optimize the timing of the sample entry prompting (Pejovic et al., 2015). Fourth, upon permission of user, lots of information could be seamlessly captured by researcher apps through APIs (Application Program Interface) with the mobile's operating system and other applications. Although only the first benefit is relevant to the current research study, publishing the Application on the aforementioned mobile application stores paves the way for the other benefits in subsequent and follow-on studies, scaling the research at with very marginal extra expenses.

Software choice:

Facilitating the innate difficulty for social science researchers to design and develop such applications a number of customizable frameworks have been developed. Among the earlies, and most used, of such frameworks is MyExperience (Pejovic et al, 2015) . MyExperience is “a system for capturing both objective and subjective in situ data on mobile computing activities” (Froehlich et al, 2007, p.1). MyExperience runs on both PDAs and cell phones, and it combines “passive logging of device usage, user context, and environmental sensor readings,” with “active context-triggered user experience sampling to collect in situ, subjective user feedback” (Froehlich et al, 2007, p.1). EmotionSense is another such framework and active application in the Android application marketplace (Pejovic et al, 2015). It collects data in “human interaction studies based on mobile phones... [it] gathers participants' emotions as well as proximity and patterns of conversation by

processing the outputs from the sensors of off-the-shelf smartphones” (Rachuri et al., 2010).

Both MyExperience and EmotionSense were judged unsuitable for the purposes of this project, hence an App had to be custom-built. MyExperience works on Windows mobile phones, which are very rare among mobile users and, at the time of the software decision, EmotionSense worked only on Android phones. Working on both Android and iOS phones, the two operating systems with the greatest market share, was necessary to reach the intended audiences. On another note, both mobile applications are heavily concerned with automated capture of data through the phone’s sensors, a feat increasing the technical difficulty of customizing the tool, and not needed for the purposes of this research project. The framework extended for this research project defined very specific variables for the interactions, resources and topics of learning, and very specific relationships between the variables. An evaluation of the customizability of MyExperience and EmotionSense revealed considerable difficulty, if not impossibility, of customizing the platform to collect the precise data required for this research.

Inspired by EmotionSense, and other applications, this study uses a mobile-based application to collect data about sample learners’ specific learning interactions. Collecting, as little as, one learning interaction per day promises to depict very rich and detailed pictures of learner ecologies, which could then lend itself to advanced analyses, identifying various configurations and patterns for ecologies and engagements.

4.1.2. Qualitative Research Design

As mentioned earlier in this document, qualitative data collection and analysis methods had been deemed necessary to complement quantitative data collection and analysis. While exploring an understudied phenomenon, qualitative analysis of complementary semi-structured data, is always necessary to re-visit the framework extended for quantitative data collection and analysis. The fact that a tool had to be custom-built for the purposes of this research had put the richness and accuracy of the contextual descriptions of the learning interactions, collected through this tool, at risk. Richness and accuracy are necessary as they are the basis for answering RQ2 pertaining the elements of personal ecologies and how they vary. Bringing richness and accuracy, qualitative data was intended to re-code the data collected by the App. Finally, although the App does capture the interactions' data, it does not capture the reasons behind deciding to pursue those interaction, which is integral to uncover the answer to the second research question, explaining the development of learning ecologies of lifelong learners.

Participant Observation

Directly observing, at least, a common factor of the research participants' learning experiences had been deemed necessary. Aiming to understand how learning ecologies vary from one lifelong learner to another, and uncovering the reasons behind these differences, meant that having a shared experience among all the research participants was necessary. This shared learning experience, availing to all participants similar resources, and requiring them to interact on a similar timeline and with similar intensities, would serve as a benchmark for comparison, highlighting the differences between the common designed experiences and the individual

resultant learning ecology. Triangulating this fraction of the participants' self-reported learning data by the researcher's direct observations would help validate the data and uncover how accurate a representation of the social reality it is.

Aiming to move beyond simple triangulation, to gathering thicker knowledge about participants' shared experiences, participant observation, seemed to be a good strategy. Participating in the shared experiences meant building stronger rapport with the learners, which would facilitate deeper interviews in the follow-up stage. Furthermore, it will bring insights with regards to the shared interactions reported into the App. Designing and moderating the experience meant that the researcher could intentionally include a variety of learning resources and offer a variety of opportunities within the experience, as shall be shown in section 2.4 describing the details of the online course. This variety is very useful as it would avail patterns in specific types of resources and opportunities, following the conceptual framework extended for the thesis.

Choice of setting:

The researcher, an instructor and trainer delivering a multitude of courses, had been running a successful online course titled "Introduction to Education" to students located mostly in Cairo for the third time in 2017. Learnapp, had been used as a learning diary /reflection tool in the second run, paving the way for understanding some of the social dimensions associated with learning. And had been planned to be part of the third run's experience. Considering the high demand on the third run of the online course, an opportunity was spotted in accepting more students, opening

more than one class, and using the online course as the context of this research study, and enlisting the course participants as the research participants.

Among the various learning experiences delivered by the researcher, the “Introduction to Education” course was most suitable. The course’s learning pedagogy was centred around facilitating the interaction of the course participants with a variety of resources, which was congruent with the purposes of the research, exploring such interactions and the resultant ecologies. Furthermore, the course extended over the optimal period of time required for data collection, namely 8 weeks, as highlighted earlier in the duration of sampling.

In-depth follow-up interviews:

On a rather primal level, semi-structured interviews probing around the topics, interactions and resources making up the ecologies, allow for reconsidering the framework extended for this thesis describing learning ecologies of lifelong learners. Guiding structured data collection, a precise conceptual framework describing learning ecologies of lifelong learners had been necessary. Improving upon this conceptual framework, defining the differentiating elements making up the learning ecologies of lifelong learners, partially answering the first research question RQ1, necessitates collecting more data around the ecologies and the interactions building them than that structurally collected. Semi-structured interviews simulated by the structured data logged collect this rich data allowing for iterating upon the conceptual framework.

Interviews were necessary as a data collection for triangulation and for revealing the intentions, motivations and reasoning behind the various interactions, topics and resources logged by the research participants. Interviews were intended as an opportunity to validate the learning logged, and the various descriptive variables inputted by the participants. Furthermore, they were intended to illuminate what has not been captured by the logged processes, i.e. undocumented topics, resources or interactions, and the reasons behind the participants' decisions to exclude these. Structured data simply reveals the participants' chosen alternative, and it leaves out the options from which this alternative had been chosen. For example, it reveals the lecture attended, and it does not reveal those lectures dropped or missed out. Interviewing allows probing into all these dimensions illustrating how the ecologies have developed, and explicating the agency versus structure dynamics necessary to answer the second research question RQ2.

Other Data Collection Methods:

Collecting data from within a bounded community sharing a learning experience is a rich way to enlighten the research questions. The learning experience had been document-rich entailing a variety of participant submissions, from enrolment into the course through assignment submissions, all the way to participants' reflection statements.

4.1.3. Methods of Previous Studies

Context, Sampling and Learning Topics in Previous Studies

Barron's learning ecology framework and the associated empirical findings, upon which this research was largely built, came about through four main research projects. The earliest, conducted in Bermuda, entailed the provision of a sequence of computer courses to students ages 14 – 18 whilst studying the two-way relationship between these courses and their prior and post overall technology learning ecologies and expertise (Barron, 2006; Barron et al., 2007). The second, conducted in Silicon Valley, entailed studying the relationship between learning ecologies of middle and high school students and the development of technological fluency (Barron, 2004, 2006). This second study compared two schools in two different communities; an affluent community and another economically diverse community with a high percentage of recent immigrants. The third, labelled Digital Youth Initiative, undertaken in Chicago, was a design-based research study, spanning over 3-years, entailing the provision of learning opportunities and tools for urban youth to develop creative digital fluency (Barron et al., 2014; Barron, Levinson, et al., 2010). The fourth, and final study, situated in Maine, is Vital Signs, a design-based research, for science learning (Crowley et al., 2015). She used surveys and interviews in all of her studies, with the number of participants in surveys ranging from 48 to 400 students, and in the interviews from 9 to 48.

Considering the context, sampling and learning topics in her studies, Barron has emphasized in several publications the need to conduct learning ecology studies in new contexts, with different ages and considering a variety of learning topics. The

proposed research, as shall be elaborated upon in the section 4.3.5, hence intends to bring about greater generalizability.

Data Collection Methods in Previous Studies

Barron uses a Learning Ecology Interview to depict a learner's learning ecology (Barron et al., 2009). The interview takes anything from 20 to 80 minutes. It entails a simple diagram showing school, home, library, community centres, and/or other settings of the learner's development. It is focused on the learning of a specific domain, which includes a set of content-topics and skills, tracing the history of this learning from its very beginning. Questions in the interview move from one setting to the next asking about the social, ideational and material resources in these settings. Questions also explicitly ask about the specific activities, or proximal processes, taking place within these various settings.

The interviewing process undertaken by Barron to depict learning ecologies is mostly retrospective, asking students to recall who and what they have interacted with for advancing their learning within a specific domain, in a specific period of time. Barron et al have indeed augmented their data with similar retrospective interviews with parents and mentors. However, these methods of data collection still confront the problems of distant information recall. Furthermore, lots of the rather micro interactions taking place are left out, hence the depiction of learning ecologies is potentially severally lacking. Barron (2010), echoing Erickson (2002), has indeed called for changing the unit of analysis in ecological studies to the daily interaction

taking place. The methodology proposed for this study takes the learning interaction as the unit of analysis, hence potentially providing a much more detailed depiction of learners' learning ecologies.

4.2. Learmapp, the mobile application

As mentioned earlier, none of the existing applications and frameworks capture the type of data necessary for this research study, hence, a custom mobile-based application had been built to collect data about sample learners' specific learning interactions. Collecting data about, as little as, one learning interaction every other day promises to depict very rich and detailed representations of learner ecologies. These representations could then lend themselves to advanced analyses, identifying various patterns of variation amongst ecologies along time, across topics, and between people. Furthermore, the structured data could well serve as a stimulus facilitating subsequent interviews, which would in turn collect more data about the choices behind the various learning interactions.

The mobile application custom-built for this study has been positioned as a structured learning diary application intended to help its user track her learning and eventually map out her learning ecology. It has been branded Learmapp. Learmapp had been designed by the researcher and developed by a freelancer, who was commissioned by the researcher. Considering the need to have it available on both Android's PlayStore and Apple's AppStore a hybrid development platform called Ionic had been used to develop the application.

Serving its intended purpose, to help its user track her learning and eventually map out her learning ecology, Learmapp had to include features structuring and facilitating the logging of learning interactions, and other features facilitating the reflection upon learning journeys and learning ecologies. The latter features were deemed necessary to motivate the users of the Learmapp be as exhaustive as possible when logging their interactions. To achieve these features, Learmapp had been developed iteratively, and two iterations have been piloted before the final release on the mobile application stores.

The subsections below detail the core logging features of Learmapp, the reflective features and the iterative development journey.

4.2.1. The App's Core Logging Features

In Learmapp, a couple of introductory screens introduce the purpose and use of the application. After that a disclaimer has been presented requesting permission from the user to use his data for research purposes. The statement had no default option, avoiding the effects of the default bias. The learner then fills in some profile information specifying the gender, work status, academic status, and academic field.

The learner is then requested to specify the topic to be learnt and offered a number of examples, setting the scope of the learning topic. After adding the topic, the learner is asked to specify the reason for learning the topic choosing from four options: Academic/degree requirement, Work requirement, Interest-based learning and other. Furthermore, the learner is asked to identify the current and target

mastery levels on scales of 1 to 10. Finally, the learner is asked to specify a target number of hours of learning for this topic per week, choosing between five ranges; 1-2 hours, 2-5 hours, 5-8 hours, 8-12 hours and more the 12 hours.

Beyond this new user onboarding experience, the learner is required to log his/her learning interactions consistently. Following on the theoretical framework, extended for the purposes of this study, the learner is required to specify the resource he has interacted with allowing for learning. Resource labels/names are inserted, and they're identified as a "person" or "thing". The specific relationship is identified for *persons* between being a manager, teacher, family member, peer, or other, specifying this other relationship. In the case of a *thing* the choice is between being a book, article, other text, audio-visual media, software, hardware, or other, also specifying this other type³.

Unlike the topic and resource details which are specified in one screen, the learning interactions are specified through 5 consecutive screens (refer to Appendix C for screenshots of all Learnapp's screens). The first screen requires the specification of resources interacted with, providing the option to add multiple resources per interaction. Instructions concerning the option to add multiple resources is explicated on the screen, and a small plus '+' sign allows such addition. The second screen requires describing the interaction with one, such as reading or lecture, and specifying the topic of the learning interaction. The third screen requires the specification of the date, start time and end time. The fourth screen requires specify

³ These categories, for both *persons* and *things* were the categories used in the App in data collection. The categories represented in section 3.3 represent the categories iterated through the findings of the study.

whether the interaction was an online/digital/virtual interaction. Furthermore, it requires identifying the specific location in which the interaction occurred. Finally, the fifth screen requires rating the interaction on a continuous five star scale, and optionally logging some comments concerning the interaction. Figure 9 shows the main categories of items logged into the App, and the variables/fields associated with each category.

Users	Interactions	Topics
Gender	Resource(s)	Topic name
Work Status	Description	Reason for Learning
Study Status	Topic	Current Level of Mastery
Academic Discipline	Date	Target Level of Mastery
	Start-time	Target number of hrs / week
	End-time	
	Digital or not	
	Location	
	Rating	
	Comments	
Resources		Locations
Resource Label		Location Name
Person/Thing		
Relationship, if Person		
Type, if Thing		

Figure 9 The Data Logged by the User into Learmapp

The resources and topic of the interaction are to be chosen from a drop-down list of those resources, topics, and locations already logged into the application, with an option to add new, referring to the designated addition screen, then back to the relevant interaction addition screen once the resource/topic is added. The location of the interaction is specified through an autocomplete field, that feeds its list from locations previously submitted to the Application. New locations are automatically added without opening the location addition screen. Resources, topics, and locations could be added independently through links in the Resource, Topics, and Locations

listing screens accessible through the App's main menu. The default home screen is the list of interactions and is also accessible through the App's main menu. The App's main menu also clearly shows an email address to contact for any inquiries.

4.2.2. The App's Reflective Features

Furthermore, a reports screen is accessible through the main menu. The reports screen shows a bar chart of hours spent learning. The user can choose to view the hours per month, per week or per day, navigating forwards and backwards from the current point in time. Furthermore, a doughnut chart shows the breakdown of hours along the various specified topics of learning. These reporting features have been added to provide the users of the application with a return on the time invested logging their learning, providing insights about their learning.

4.2.3. .The Iterative Development of the Mobile Application

Due to the innovative nature of the application it had been planned to evolve over two iterations of development and user testing. Each iteration had been planned to include around 10 users/participants. Convenience sampling had been used to choose the participants in the two iterations of user testing. Users had been requested to use the application for two weeks upon which a semi-structured interview had been conducted to explore their user experience, and the accuracy and completeness of the information collected.

The development of the App had been self-funded by the researcher. A visual design company was contracted to develop the User Interface of the App, according to Wireframes drawn up by the researcher. And a freelance mobile developer was contracted to build the application.

Along with the main two iterations and the final release a number of changes were undertaken. On the resource front, instead of labelling a resource as “social” or “material” the aforementioned label of “person” and “thing” were used. Furthermore, the specific social resource relationships and material resource types were modified to suit the adult learning setting. Whilst logging a resource a field requiring specification of the ‘resource that led to this resource’ had been dropped, as this loop was observed to damage the customer experience. Adding new resources whilst adding interaction from the ‘Add New Interaction’ screen had been facilitated.

All the fields associated with the ‘Complete Profile’ and ‘Add New Topic’ screens had been added through the latter iteration and final release. The sequence of the 5 interaction screens had been amended two times to be as intuitive as possible. Logging time had been modified through the iterations to be more intuitive too. Required fields were specified and error messages were added as well.

4.3. The details of the online course and the course participants

As mentioned above, data for this study has been collected through an online course titled "Introduction to Education". The researcher was the course facilitator. The course has run for two times prior to the data collection instance. *Learnmapp* has been used as a learning diary in the second run of the course, successfully

facilitating the understanding some of the social dimensions associated with learning. It had already been planned to be used in the third run too. The third run, thus, was poised as a prime context for exploring the questions posed in this thesis. The course, as a designed environment, made specific resources and opportunities available to its participants along a specific timeline. Comparing the actual interactions with those prescribed through the course design, and across participants, has been one of the main analytical endeavours of this research study. The following subsections provide important background information about the admission process into the course, its structure, the required and recommended learning resources, assignments and deadlines. The final subsection describes the course participants. It is important to note here that the participants' learning ecologies under investigation were not confined to those associated with the course, rather, the data that has been collected, and is being analysing, covered the totality of the research participants' learning.

4.3.1. Admission

Similar to its predecessors, the third run has been advertised on social media, specifically Facebook and WhatsApp. The course has been advertised as an introduction to educational studies, covering a broad range of topics, including Educational Philosophy, Social Foundations of Education, Human Development Theories, Learning Theories, Curriculum Design, Teaching and Research Methods, all certainly on a very shallow introductory level. The course also promised to target a variety of 21st Century skills, including critical thinking, creativity, communication skills, analysis and synthesis among other skills. The course identified various actors

or intending actors in the fields of alternative education (such as alternative school teachers, curriculum designers, school administrators, and home-schooling parents) as is its target audience, promising a number of subsequent courses equipping such agents to fulfil their innovative mission. The informational post identified three requirements for the course; attending 8 online sessions, reading the assigned resources (most of which will be in English language) and doing the group and individual assignments (written in Arabic language). Finally, the adverts highlighted the price of the course.

Applying to the course, candidates were requested to fill out an application form made by Google Forms. The application covered demographic information, occupation and academic qualifications, self-reported level of English language proficiency, and hours available to commit to the course per week. Furthermore, the application form demanded a short personal statement highlighting the applicant's motivation for the topic of education generally and for enrolling into this course specifically.

More than 150 applications were received for the third run of this online course. The online course has been designed to admit been 15 to 20 participants. As such it has been decided that two concurrent runs of the course will be conducted. Two criteria, namely self-reported level of English language proficiency and number of hours available to commit for coursework, were initially used to filter-out candidates. Then the personal statements submitted were used to evaluate the candidates' motivation and writing abilities. The top 60 candidates received acceptance notifications, entailing information about the weekly meeting time of each of the two cohorts and

requesting accepted candidates to specify their preference and finalize payment for the course. 42 accepted candidates specified their preference and paid the course fees.

4.3.2. Structure

The course was designed to run over around 8 weeks and required no physical presence at any point during the experience. Weekly sessions were planned for the first 8 weeks, and 2 further weeks were allowed for submitting the final/remaining assignments. A total of 8 course weekly sessions were scheduled for each of the course cohorts. Weekly sessions, for both cohorts, were conducted back-to-back on Saturdays. Participants were given the option to attend two of the sessions face-to-face in a co-working space in Cairo, however, even those two sessions were accessible online. Those two sessions were the second and eight sessions. The online sessions were conducted using a paid account on the online communication platform Zoom. Zoom enables all participants to engage in voice, video and text discussions.

The weekly sessions were structured around discussing pre-assigned readings and/or assignments. Chalkup.co has been used as the Learning Management System for the course. Readings were uploaded on the Chalkup platform. Assignments were posted, scheduled, and submitted through, the platform. Requirements for each week (i.e. readings and assignments) were posted, and

discussed, in Chalkup's discussion segment. The discussion segment also hosted several other discussions initiated by both the researcher/instructor and participants. The two cohorts were enrolled into two separate spaces on Chalkup, however, they were allowed to occasionally attend the weekly sessions with the other cohort.

Table 3 Online Course Timetable

Session No.	Date	Meeting place	Resources (Required and Optional)	Assignment (Deadline)
1	4-Nov-17	Online	1. <i>Video*</i> : "Changing Educational Paradigm" by Sir Ken Robinson 2. <i>Video</i> : John Dewey's Philosophy of Education through Coursera 3. <i>Article*</i> : "John Dewey" by Robert B. Westbrook	
2	11-Nov-17	Online/Fac e-to-face	4. <i>Book Chapter*</i> : "What is Philosophy of Education?" by D. C. Phillips	17/11 Research Questions
3	18-Nov-17	Online	5. <i>Book Chapter*</i> on History of Education (<i>in Arabic Language</i>)	20/11 Educational Philosophy Comparisons (Group Assignment) 24/11 Personal Educational Philosophy Version 1
4	25-Nov-17	Online	6. <i>Book Chapter*</i> : "Understanding Education: The Role of Sociology" by Alan Cribb and Sharon Gewirtz 7. <i>Book Chapter*</i> : Theories and Methods in Sociology of Education	
5	2-Dec-17	Online	8. <i>Book Chapter*</i> : (a) Educational Psychology Salvin or (b) Educational Psychology Santrock 9. <i>Article</i> : The Content of Educational Psychology 10. <i>Article</i> : The Social Side of Schools 11. <i>Book</i> : How to Formulate Research Question	5/12 Filling Up Research Question Form
6	9-Dec-17	Online	12. <i>Thesis*</i> : Redefining Education 13. <i>Book Chapter*</i> : How-We-Learn-Learning-and-non-learning-in-school-and-beyond 14. <i>Book Chapter*</i> : Educational-Psychology-Theory-and-Practice-8th-Edition-.pdf 15. <i>Video</i> : Beyond the Classroom 16. <i>Book Chapter</i> : A Comprehensive Understanding of Human Learning	22/12 Methodology Section 22/12 Literature Review
7	16-Dec-17	Online	17. <i>Thesis*</i> : Redefining Education V 6 (Section 1) 18. <i>Book Chapter*</i> : Disrupting Class	
8	23-Dec-17	Online/Fac e-to-face		2/1/2018 Educational Research Project

4.3.3. Resources

In terms of material resources, a total of 13 resources were required from each participant. Only 2 of these resources were videos, and the remaining 11 were articles or book chapters. Twenty more optional resources uploaded on Chalkup brought the total to 33. The interaction with required resources was encouraged through the provision of brief description of the readings/videos and the key questions to try to answer through the resource. Furthermore, from the very first sessions it had been made clear that the sessions revolve around discussing the readings, rather than presenting them, and that the summary will be provided by the students themselves. Cold calling to explain specific readings, or parts of readings, had also been utilised early on, pushing the course participants to interact with all required resources. Participation was highlighted to amount to 30% of the total grade of the course.

Optional resources were either provided as alternatives, from which the student was required to choose one to read, or as complementary material. As such, optional resources were availed to encourage the interaction with the required resources and expanding upon them.

4.3.4. Assignments

Four strands of assignments were required of the course participants. First, working in groups, participants were required to draw up a comparison between the educational philosophies of two major thinkers using specific articles. These philosophical comparisons comprised 15% of their grades. Second, they were

required to log their daily learning on the App, Learmapp, or utilising any other method they prefer. This strand built up into a reflection essay that was submitted after the conclusion of the course experience, making up 15% of the total grade of the course. Third, participants were assigned multiple micro-assignment along with an educational research project, to be submitted two weeks after the final session of the course. The micro-assignments entailed formulating research questions, iterating on them, conducting and writing a brief literature review and designing a research project to answer these research questions. These micro-assignments were not graded; however, participants were offered timeslots for virtual synchronous feedback on a developed version of the research question. Only the final submission of the research project had been graded making up 25% percent of the total grade of the course. Fourth, participants were required to write up a personal educational philosophy statement on two iterations, once in the beginning of the course, and once towards its end, the first iteration was not graded, however, recorded voice feedback was provided. The grade for the educational philosophy, totalling 15% of the final grade, was awarded based on the final iteration's submission, weighting into the grade the development from the first to the second iteration. The instructor had taken notes throughout the course experience noting the participation level of the various students, accounting with the session attendance as mentioned previously for 30% of the total grade of the course.

Table 4 Grade Breakdown

Attendance and Participation	30%
Comparison of Educational Philosophies	15%
Personal Educational Philosophy Statement	15%
Educational Research Project	25%
Reflection of Lifelong learning Journey	15%

4.3.5. Participants

Although a total of 42 participants enrolled into the course, only 24 participants' have been included in this study. 8 of participants dropped out of the course at some point during its 8-week duration, bringing the total number of those who participated till the end 34. Out of those, 8 provided less than 10 interaction data points and 2 had provided very incomplete data.

In terms of demographics, all participants lived in Egypt except two, one in Qatar and one in the United States. All participants were Egyptian with the exception of one Syrian. Most of the participants, precisely 21, are females, the vast majority of which are housewives; only one of those females works full-time and 3 work part-time. Ages, at the time of participation in the research, ranged from 20 to 43, with a median age of 29. The 43 years old is an outlier.

4.4. Details of the data collection methods and sources

A multitude of data sources were utilised to answer the intended research questions. These sources include first and foremost the learning logs, created by all 24 research participants as they used Learnapp, or alternative means. Of equivalent importance are the interview transcripts emerging from the in-depth follow-up interviews conducted with the 24 research participants. Furthermore, the researcher's field notes and several documents written by research participants are amongst the data sources, of special note among these are their reflection essays submitted towards the end of the course, and their application forms submitted at the outset of the course. The final data source has been a name generator survey

conducted post-course to triangulate the data collected through the App about social resources.

The learning log, interview and name generator survey were conducted by each of the 24 research participants. The logging method differed among the participants, as shall be elaborated in the coming section, and shown in Table 5 below. Furthermore, as the table shows, submissions have not been received from all research participants. The section below elaborates on the details of the data collection process and sources.

Table 5 Participant's Data Submissions Summary

Participant	Logging Method	Reflection Document	Application Form
Sandra	Learmapp	Yes	Yes
Nancy	Learmapp	Not Submitted	Yes
Sarah	Learmapp	Yes	Yes
Jay	Learmapp	Yes	Yes
Adam	Learmapp	Yes	Yes
Alya	Learmapp	Yes	Yes
Sandy	Learmapp	Yes	Yes
Angie	Learmapp	Yes	Yes
Hannah	Learmapp	Not Submitted	Yes
Dana	Learmapp	Yes	Not Submitted
Farah	Learmapp	Yes	Yes
Sally	Learmapp	Yes	Yes
Daliah	Learmapp	Yes	Yes
Layla	Learmapp	Not Submitted	Yes
Dima	Learmapp	Yes	Yes
Maya	Learmapp	Yes	Yes
Kenzy	Learmapp	Yes	Yes
Ali	Learmapp	Not Submitted	Yes
Noah	Learmapp	Yes	Yes
Sherry	Other	Yes	Yes
Lina	Other	Yes	Yes
Nader	Other	Yes	Yes
Hanzada	Other	Yes	Yes
Randa	Other	Yes	Yes

4.4.1. Learning logs

Learning logs are the main data source used in this research study. Students had been informed before being requested to consent to participate in the research and had been given the opportunity to safely opt-out of the research study (whilst continuing to use the app for the course). Students were asked to go through of the information sheet and consent forms twice before consenting; (1) in the

assignment's briefing and (2) in the version embedded within the application. They were assured that they can opt-out of the research study, withdrawing their data from the analysis stage. They were given the chance to opt-out after receiving the final grade of the course.

Participants were given the choice between using Learnapp to log their learning throughout the course, using a simple paper and pencil, or word processor procedure, for logging such learning. To facilitate manual recording, participants who opted to use a manual system to log their learning were requested to log only interactions' data specified in Figure 9 above. Precisely for each interaction they were required to specifying (a) the date, time, and duration of the interaction, (b) the location in which the interaction took place and whether it was digital, (c) the topics of the interaction, (d) the resources interacted with, (e) the rating of the interaction on a scale of 1 – 5, and (f) general comments about the interaction. Details pertaining to the participant herself, topics logged, and resources interacted with were left to be collected through the interviews.

For the 24 included in this study, 19 used the Learnapp to log their learning interactions' data and 5 used alternative means; two participants reported their data in tabular form in Microsoft Excel, two reported their data in Word, one of which was also in tabular form, and one reported pictures of handwritten notes.

4.4.2. Interview

The learning logs were mainly used for quantitative analysis. However, to confront the problem of recall, which happens with retrospective interviews, these learning

logs, were used to include a level of richness that would remind the interviewees of the details of their learning journeys.

The interview started by going through the information sheet and asking for permission to audio-record. Then for validation purposes, they were asked about the answers submitted online for the name generator survey, to be elaborated upon later. They were then asked to indicate which of the material resources availed through the course they have interacted with.

The core of the interview revolved around the interactions and topics logged. Probing into interaction entailed completing any missing information and inquiring about the reasons behind choosing the specific resources they did, in the interactions, and creating or making use of the specific opportunities captured. If needed, as indicated by the preparatory analysis done by the researcher, the locations of learning and resources interacted with might have been better identified. Probing through topics entailed collecting missing information, requesting more details and inquiring about the progress from current level of mastery to the target level of mastery during the period from early November to late December 2017.

An important part of the interview entailed inquiring about the level of support provided by the learning ecology and what would improve it. This question was asked on both topical and overall ecological levels. Learning was identified learning as an important factor in personal wellbeing and inquiries on the ecological support provided towards this end. Throughout discussions of learning ecologies participants were reminded of their agency with the words “the ecology you created for your learning”.

Finalising the interview, participants were shown three charts. One chart showed the interactions/time per week over the 8-week period, another showed the total number of interactions logged in each of the hours of the day, and the third showed the total number of interactions logged in each of the days of the week. This has been intended to validate the time logged, and to uncover reasons behind specific patterns if any, e.g. specific times of day when children are sleeping.

Another process of provision of information and consent request had been pursued before conducting the interviews. Interviews had been scheduled, through Doodle's online scheduling platform, and conducted and recorded via Zoom, an online meetings platform. The scheduled interviews lasted from 40 to 90 minutes. They were reported by many of the participants to be insightful. Interviews were conducted and transcribed in Arabic. Transcription was undertaken by four different freelancers.

4.4.3. Student Submissions

As mentioned earlier, the learning experience had been document-rich entailing a variety of participant submissions, initially enrolling into the course, through application forms, and fulfilling its requirements, through assignment submissions, including the reflection statements. These documents involved lots of background information concerning the research participants, which helped contextualise learning log data and interview transcripts.

Reflection Essays

The reflection essay required participants to specify topics they have pursued during the period of logging and discuss and reflect on the reasons behind learning these various topics. They were required to specify the resources availed, during the period of logging, and identify those from which they have benefited the most. They were required to identify places in which they have spent time learning, highlighting the ones which they prefer and the reasons behind that. Similarly, they were required to identify the times of the day in which they learned, their preferences and reasons behind them. They were requested to identify the types of interactions they engaged in and elaborate upon their preferences. On a general level, they were asked to reflect on the experience of logging their learning, and for those who have used the application, the experience of using Learmapp.

It was mentioned that these questions were mostly for guidance and that they could take the reflection essay in any way they wanted. They were required to submit 500 words to fulfil the requirements of this specific assignment. As shown in Table 5, all participants submitted reflection essays except four.

Most of the reflection essays were submitted before the interviews were conducted serving two very important functions. First, they prepared the participants for the discussions, again refreshing the memory and developing their understanding for their learning journeys, interactions and ecologies. Second, they helped the researcher develop a better understanding of the submitted data before the interview.

Application Forms

As mentioned earlier, applying to the course, candidates were requested to fill out an application form through Google Forms. The application covered, among other things, demographic information, occupation and academic qualifications, all of which is important data building up a better understanding about the research participants. The application forms requested further information concerning the course topic, such as the hours available to commit to the course per week, and the motivation for the topic.

The personal statement demanded the participant to contextualise the motivation towards the topic of education more generally, and towards the course specifically, both by relating to his or her past and present experiences as well as future aspirations. The personal statement requested around 750 words divided between three questions in Arabic, the translation of which is below:

- 1) Why are you interested in the field of education? How's are you currently pursuing/putting into action the interest? How are you planning to impact?
- 2) What's your motivation for enrolling into this specific online course? What personal outcomes are your expecting?
- 3) What's interesting about you? What are your talents, your achievements, your topics of expertise? What will you add to this course? Considering the number of seats available in the course is limited, why should we choose you?

Those application forms are important source of data for this research. Given that the course, and its topic, were common to all participants, comparing participants'

responses, prior to the course, to those questions, concerning time and motivation, are very useful points of comparison. They possibly explain some of the variance in the topical learning ecologies. As Table 5 shows, all of the participants but one, submitted their application forms to Google forms. This one participant, however, had an oral interview which was unfortunately neither recorded, nor noted down in any way. Participants have consented orally, to the use of their application forms, during the interviews.

4.4.4. Observations

The online course was participatively observed by the researcher. The researcher had been keeping attendance, an important document to contrast with the actual meetings logged by the individual research participants. Some participants have attended, but they have not logged their attendance into the app. Furthermore, notes were kept concerning participants' engagement in the discussions of the various material resources, again, with the section of the interview covering interaction with material resources, triangulating the data logged into the application.

Difficulties using the app or logging learning interactions more generally, brought up in the classroom discussion, were tracked in timestamped notes. Participant general circumstances were also noted. Most of the notes have been brought up in the respective interviews with the individual participants.

4.4.5. Name Generator Survey

A name generator survey had been designed and circulated to validate the social resources logged using the app. Furthermore, naming the social resources actually

interacted with, in a bounded community, reveals some aspects around the social position assumed by learners in bounded social learning environments, further illuminating the social aspects of the learners' learning ecologies.

The name generator survey requested participants to name the top three people they reached out for advice and the top three people who sought their advice throughout the duration of the course. Questions were open ended. The word "advice" was used to allow for directionality, as words like "learning partners" or "collaborators" do not allow for such directionality. The number of listed names was limited to three, to enforce as a sense of prioritization in answering the question.

4.5. Details of the data analysis

As mentioned previously, analysis had started well before the actual data collection. Data collected through Learmapp during the piloting phase had been subject to quantitative analysis. A personal reflective, and analytical, essay had been written by the researcher making sense of his personal data. Preliminary analysis had been conducted parallel to the interviewing stage as a way to enrich the interviews.

Beyond data collection, analysis had been iterative, moving from quantitative to qualitative in three stages, with different challenges for each of those stages. The three stages roughly map onto the three findings chapters (Chapter 5, 6, and 7).

First Stage of Analysis

In this stage, the framework, presented in chapter 3, was used to analyse four case studies and to conduct case comparisons. On one level, these case were used to inform and update the conceptual framework. On another level, the analyses and comparisons explored the development and outcomes of learning ecologies as exhibited in these four cases. A general theme gauged and probed into throughout the case studies is the degree of difference between the ecologies as captured by the app versus the other data collection methods.

In addition to mapping the participants' data to the framework, case analyses entailed an elaborate process of qualitative coding and theming of factors influencing satisfaction in the four participants' interview transcripts. This extraction of factors has been scaled, in the third stage of analysis, to the whole sample. The narrative and elaboration provided in the case studies was used to inform the evolving framework.

This comparative analysis started by comparing the 'Education' ecologies of the four learners, as all of the learners pursued the topic 'Education' primarily within the affordance of the 'Intro to Education' course. Comparative analysis then moved on to comparing the remaining topical ecologies of the four learner cases. Finally, the comparative analysis compared a number of metrics describing the ecological parameters across all four overall learning ecologies, comparing the findings with those observed on the topical ecological level.

Second stage of analysis

The second stage focused on scaling the analysis to the whole sample. One main challenge was identifying and evaluating metrics to measure the various ecological parameters related to topics, resources, and contexts. To calculate these metrics, comparably, for all sample participants it was necessary to re-code some of the participants' categorisations of resources and contexts. The coding schemes enacted by the participants were qualitatively analysed.

Having cleaned the structured data, each of the ecological metrics, or variables, was univariately explored and described. Following on the findings which have emerged from the first stage of analysis, most variables were measured on multiple different levels of analysis (such as the topical and overall ecological levels⁴) for comparison. Bivariate analyses had been conducted exploring the relationships between some of these variables.

Third stage of analysis

The third stage of analysis was focused on exploring the relationship between ecological metrics, identified in the second stage of analysis, and the outcome variables. This stage entailed both quantitative and qualitative inquiry. The quantitative inquiry covered first the variance among learners along the main outcome variable categories and the relationship between these outcome variables

⁴ An overall ecology is comprised of multiple topical ecologies. The sample entailed 24 overall ecologies (equal to the number of participants), and 121 topical ecologies (as most of those participants pursued multiple topics simultaneously, as shall be shown in the findings).

and one other. A second set of quantitative analyses focused on the relationship between those outcomes variables and the ecological parameters described in the previous chapter. The qualitative inquiry focused on one of those outcome variables, namely satisfaction, unearthing, from the interview transcripts, factors affecting satisfaction and dissatisfaction with topical and overall ecologies.

4.6. Ethical Considerations

The research methodology and data collection methods proposed entail a number of ethical considerations. In the following paragraphs some ethical issues, raised by BERA (2011) and relevant to the mobile-based study proposed, are discussed.

First, is the issue of voluntary consent, research ethics mandates that a participants only takes part in a study after he provides an informed consent, based on thorough knowledge about the study, its objectives, and his/her role in it (Bera, 2011).

“Thoughtful consent” is relatively difficult to obtain as most smartphone users do not read terms and conditions before consenting to move on to downloading the application (Miller, 2012, p.231). Tackling this issue will take place through adding a couple of screens on the first use of the application with succinct disclaimer, encouraging the reader to actually read them, requesting application user’s consent of participation. Taking this path to ensure informed consent the researcher is following the precedent of Emotion-Sense, the emotion-sampling mobile application developed by researchers at Cambridge University available on Play Store for public download (<http://emotionsense.org/index.html>).

The researcher also provided a longer form of the information sheet aligned with the guidelines provided by the university for internet based research, a mentioned above, (a) as a final scrollable screen in the terms and conditions screens (b) under the settings tab in the App's main menu, (c) in an email sent to the App user to confirm registration and (d) on the App's website. Strategies (a), (b) and (d) have been utilised by The Great Brain Experiment, an App developed for research purposes by researchers at UCL, available for public download on both the Play and App Stores (<http://thegreatbrainexperiment.com/>). Strategy (c) is unique to this research. The purpose of providing continuous access to the terms of the research is to ensure that the participant is conscious of his/her participation in the research study. In all the above communication, it is made clear to the participant that he/she can withdraw from the research by deleting the App.

The second ethical issue that needs consideration, in mobile application studies, is that of participants' anonymity and privacy (Bera, 2011). In mobile application studies, participants willingly grant access to "detailed logging of sensor, call log, and GPS data... Such data would probably allow inference of a participant's identity, sex, life stage, marital status, social status, home address, health, sex life, and religion, even if those were not self-reported," hence breaching participant anonymity (Miller, 2012, p.231). The researcher in this study does not intend to infer any identity data not provided by the participant for the study.

The third issue that needs to be considered is the issue of disclosure (Bera, 2011). What if other third parties gain access to this data and perform such inferential activities? Indeed, data has been encrypted both in the upload and storage stages,

however, sophisticated processes performed by hackers and intelligence agencies might break the encryption protocols. Furthermore, “even with encrypted data uploads and privacy-preserving data analysis, a participant’s confidentiality will be vulnerable to authorities” (Miller, 2012, p.231). Whether its “totalitarian governments, fundamentalist regimes, or national-security panics, smartphone data could be commandeered to hunt down dissidents, apostates, or pacifists” (Miller, 2012, p.231). However, given the scale of this study, the researcher does not believe that a mobile application, at such an early stage of release to market and accordingly a relatively small user base, would be of much interest to hackers, intelligence agencies, or demanding authorities. As per the description of the data presented above, it is important to note that data collected is not foreseen to include any sensitive information. The researcher worked with the University’s research data team to ensure the privacy of users’ data on third party servers (third party services are leased for cloud storage and processing of users’ data uploaded from their mobile phones). Access to data on the server has been limited to the researcher. Downloading data from the server was limited to the researcher’s password protected personal computer. And data have been anonymized on the researcher’s personal computer.

4.7. The Role of the Researcher

Learmapp, the tool used for structured data collection, has been iteratively designed and piloted by, and custom-built for, the researcher. This intimate relationship with the tool has meant that the researcher is familiar with the difficulties entailed in using it and its relative and incomplete representation of reality. Deciding how to log a

specific interaction, describing it in the description section, associating it with a specific topic, recalling its start and end times, are all difficulties the researcher has went through piloting and using the App. It has led to better instructions while showing the App to research participants. This has led to a better ability at appreciating the context of using the App beyond the data it provides.

As mentioned earlier, the researcher was a participant observer in the online course which has been the site for this research. Precisely the researcher assumed the role of the course designer, instructor, discussion moderator and assignment assessor. This gave the researcher access and control over all aspects of the shared learning experience. It also allowed closer connections with the participants allowing for deeper interviews.

4.8. Limitations

The study intends to understand learning ecologies of lifelong learners by constructing representations of such ecologies through sample learning interaction data collected daily through a mobile phone application. In doing so, it potentially promises a leap in the detail level concerning learners' learning ecologies, and their patterns of engagements with these ecologies overtime. However detailed this image might be it is still based on a sample of learning interactions not all, and hence subject to errors, limitations and shortcomings of participants' self-reporting. The actual engagement with the learning ecology will always be greater than that depicted by the application, and as such even the depicted picture of the learning ecology might be lacking.

Another limitation of this study is its sample size. Bringing up the application to a technologically stable, user-friendly and visually appealing condition entailed lots of modifications, which both depleted the budget and time originally planned for this phase of the project. Furthermore, Learmapp's final features, standing alone without the researcher's direct relationship with the pilot users, failed to engage its users to log sufficient interactions. The plan for rolling-out Learmapp had to be revisited.

In the initial conception, the roll-up phase entailed releasing the application to collect data from mass audiences. The plan had entailed releasing Learmapp on both Apple's App Store and Android's Play store, available for free download, and advertising it to reach a mass user base. A sample of those would then be interviewed, as part of the third phase, for data validation, explanation and all other purposes mentioned in the previous sections.

As mentioned in section 4.1.2, describing the qualitative design aspects, changing the sample group to a bounded community, sharing an experience, which is participatively observed by the researcher had been deemed necessary. The third run of the "Introduction to Education" online course running in November and December 2017 was the most convenient opportunity fulfilling the requirements of this research. Course students were requested to download Learmapp, off of Android or Apple's application platforms, and use to log their learning over the duration of the course. Out of 42 students enrolled into the course, 19 used Learmapp to log their learning, and 5 used alternative means to log their log.

5. Describing Learning Ecologies

This chapter reports on the findings that has emerged from the first stage of analysis conducted in this research study. This thesis is at its core a proposal and an evaluation of a conceptual framework, along with associated approach for data collection, to explore learning ecologies of lifelong learners. The central research questions, around which the conceptual framework has been poised, are concerning the development and outcomes of those learning ecologies. As mentioned earlier, the lifelong learning segment is the most understudied education segment in the learning ecology literature, although arguably the LE framework brings the most promise to this segment. As mentioned earlier, in order to understand the learning ecologies of lifelong learners in their entirety, a research needs to cross not only contextual boundaries, but also topical boundaries, as lifelong learners alternate through their learning hours between various topics, supported by distinct yet interrelated topical learning ecologies.

In this chapter, the framework, presented in chapter 3, is used to analyse four cases studies and upon which it is used to conduct case comparisons. On one level these case analyses and comparisons have been used to inform and update the conceptual framework. And on another level, the analyses and comparisons had the development and outcomes of learning ecologies of lifelong learners as the main subjects of enquiry. As such each of the case studies has followed a specific structure: (1) They start by keywords summarizing the main ecological parameters protruding in the case respective case study. (2) Following is a background about the studied learner to be able to appreciate the various dimensions of the ecology.

(3) The case studies will then move on to the topics the learner has committed to learning along with motivation for her commitment. (4) The interactions furthering the advancement along the topics will be described denoting the level of activity in the respective topical ecologies. (5) The resources, the subject of the interactions, will then be detailed for each of the topics. (6) The locational and temporal contexts of interactions, along with their digitality will be noted. (7) Finally, the learning outcomes will be described, along with an elaboration on the learners' satisfaction with their respective topical ecologies. This last elaboration, on satisfaction, will start by an articulation of the main factors that have been extracted through analysis, then elaborates further on the satisfaction with the respective topics. This extraction of factors has been scaled to the whole samples for the qualitative analysis of satisfaction reported upon in section 7.3. The narrative and elaboration provided here will help contextualise the quotations, factors and themes reported there.

A general theme that will be gauged and probed into throughout the case studies is the degree of difference between the ecologies as captured by the App versus the other data collection methods. After the presentation of the four case studies a comparative analysis will be conducted. This comparative analysis will start by comparing the 'Education' ecologies of the four learners, as all of the learners pursued the topic 'Education' primarily within the affordance of the 'Intro to Education' course. The second comparative analysis will move on to comparing the remaining 10 topical ecologies of the four learners. The third comparative analysis will compare a number of metrics describing the ecological parameters across the four overall learning ecologies, comparing the findings with those observed on the

topical ecological level. This last section then leads on to the subject of the next chapter, chapter 6, reporting upon the quantitative univariant analysis conducted in this study.

5.1. Adam's Learning Ecology

Keywords

Digital / Home + In-transit / Material Resources / Multimedia

Background

Adam is married. Adam had been an expecting father at the time of enrolling into the 'introduction to education' course. Adam's educational history includes enrolling into five different higher educational institutions at various points in time. He had completed his studies in only two of these institutions. During the period of data collection, Adam worked full-time as an accountant and studied part-time for a second Bachelor of Arts, in Psychology. Adam was in his final term in a distance learning program in Psychology.

Topics

Adam's reportedly 'bad' experience in the five higher education institutions ignited, to an extent, his interest in learning more about education. This interest was amplified by expecting his first child. Considering the state of higher education, along with the

primary and secondary education systems feeding higher education, Adam was worried about the education of his expected child. Informing his choices regarding the education of his expected child was a primary driver for joining the ‘introduction to education’ course.

His interest in Psychology was indeed an old one, triggered by watching random videos and attending random lectures on the topic. Adam did not merely pursue advancement in the topic of Psychology through his distance learning program, rather, he promptly followed the lectures posted online by several experts in the field of Psychology. Indeed, the first interaction he logged into Learnmapp was that of a lecture in analytical psychology by a professor to whom he was introduced by a colleague in the distance learning program.

Beyond ‘Education’ and ‘Psychology’, starting the first week Adam logged some interactions under a topic he labelled ‘General Knowledge’.

Interactions

Adam was amongst the first research participants to download the App and start logging. His logged interactions flowed from the first session of the online course, on the 4th of November 2016, to some studying for the distance learning program on the 27th of December 2016. Figure 10 below shows the number of interactions per week, along the three topics he logged into the App, over the duration of the 8-week course.

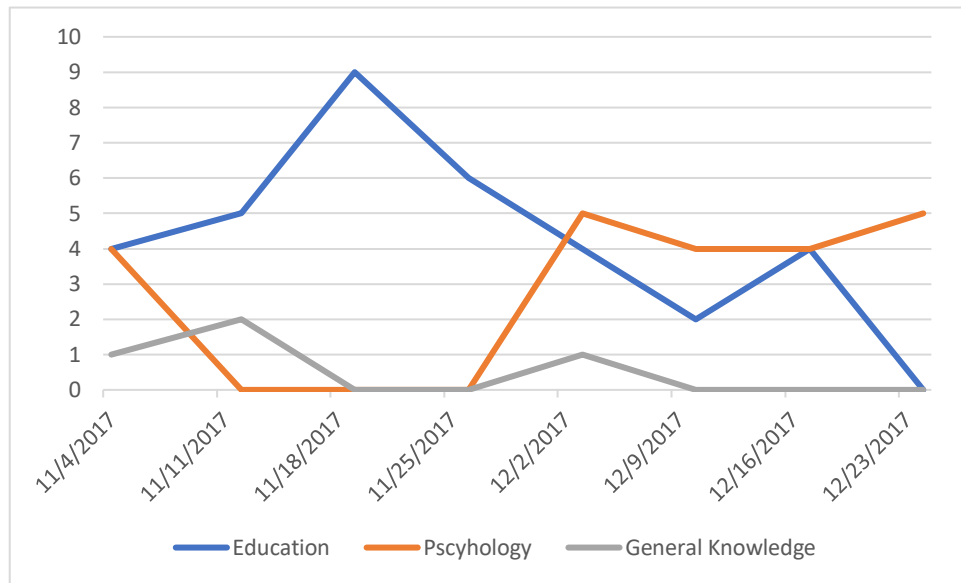


Figure 10: Adam's Number of Interactions Per Week

In Figure 10, interactions are attributed to the beginning date of the week in which they happened, i.e. the four interactions under the topic education attributed to the 4th of November happened between the 4th and the 11th. The week running from 18th to the 25th of November entailed an assignment and a longer reading associated with the online education course, in addition to an extra-curricular reading of a book on Islamic philosophy of education. The final two weeks of the logging experience, running from the 16th of December, entailed studying for the exams in the distance learning program.

Adam logged an average of 7.5 interactions per week, dedicating on average eight hours per week to lifelong learning. He logged a total of 60 learning interactions, amounting to a total of 65 hours over the 8-week period. Figure 2 below (left) shows the breakdown of the interactions, in terms of both number and duration, along the three topics. Figure 11 below (right) shows the number of resources interacted with per topic. Education had 34 interactions with 13 different resources, amounting to a

total of 40 hours. Psychology had 22 interactions with merely three resources, aggregating 20 hours of learning. And general knowledge entailed only four interactions with three different resources, summing up five hours of learning.

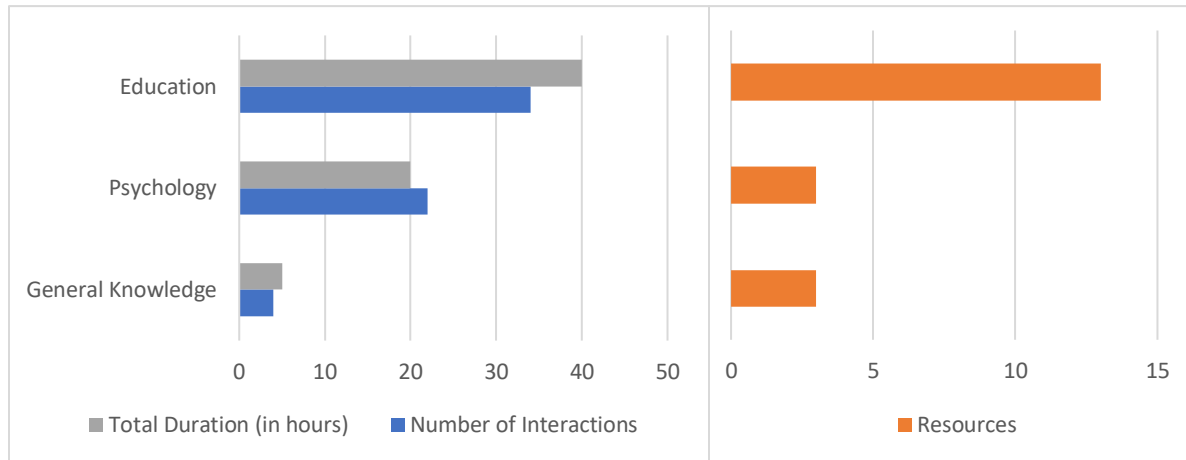


Figure 11 (Left) Adam's Number of Interaction (and hours) Per Topic, (Right) Adam's Number of Resources Per Topic

Resources

Adam's pursuit of advancement in the topic of 'education' was initiated by, and embedded within, the online course. Most of the resources Adam interacted with were material resources, readings or videos, required by the course. Apart from those, two resources were sought out and interacted with to further clarify some of the readings required by the course. One reading, namely the aforementioned book on Islamic philosophy of education, was stimulated by a relevant discussion in the course, and aimed at furthering the level of knowledge of the topic. Two resources were sought out fulfilling the requirements of the course's research project. Adam did not engage in any learning interactions with his fellow course participants except

within the group assignment. Apart from the course instructor, Adam did not log any social resources into the App.

The three resources furthering the topic 'psychology' were audio resources. Precisely, the three resources were three series of video lectures uploaded on YouTube. Adam downloaded the videos, turned them to MP3 files, and listened to them either at home, or in public transportation to and from work, as shall be elaborated later. One lecture series, mentioned before, was referred to by a colleague in the distance learning program. Another lecture series was part of the distance learning program. And the third was a recording of a lecture series, by a lecturer Adam follows very thoroughly. Adam wanted to attend some of these lectures live but failed due to work commitments.

The three resources furthering Adam's 'general knowledge' were similarly videos turned MP3. One of the three resources, with which Adam interacted twice, furthering his 'general knowledge' was initially chosen to clarify one of the readings required by the course. This lecture, however, failed to fulfil the intended purpose and thus Adam appropriated it towards his 'general knowledge' pursuit. The two other interactions, with a different resource each, were ignited by followership of specific friends, pages, or channels on social media platforms.

Contexts

Adam's interactions were primarily digital. Apart from one interaction, namely the second session in the 'introduction to education' course, all of the interactions logged by Adam were digital interactions. Adam spent his time mostly between three

localities; home, work and public transportation. However, he expanded his access to resources, social and material, through his access to his mobile device, laptop and access to the internet. 30 out of the 60 interactions Adam engaged in took place in his commute to and from work. This less contested space and time afforded two digital interaction opportunities every single weekday. Adam engaged in 18 interactions on the way to work and 12 back home. With eight common days, i.e. days in which he engaged in learning both on the way to work and from work, Adam utilised the commute opportunity in a total of 22 days out of 39 workdays.

Outcomes

Adam's overall course grade was 93% ranking third. As Table 6 below shows, Adam identified his initial level of mastery of the topic Education as a complete novice, with a target to reach a level 7 of 10, 10 denoting Masters level mastery. He intended to put in 2 to 5 hours per week. He committed 40 hours during the 8-week logging period to Education, amounting to 5 hours per week, which falls on the upper limit of his intentions. He progressed 1.5 points on the 1 to 10 mastery scale. Psychology and General knowledge had similar initial levels of mastery and target levels of mastery. However, the target hours of learning intended for psychology, embedded within his formal degree, was similar to education two to five hours, compared to a mere one to two hours to general knowledge. Adam managed to hit the target for psychology with 2.5 hours per week, however, he fell short of the target for general knowledge with less than an hour per week. For both of these topics he advanced 0.5 points on the 1 to 10 scale. When asked about his satisfaction with the support

provided by the respective topical ecologies, Education, Psychology and General Knowledge scored 70%, 80%, and 85% respectively. Overall ecology 65%.

Table 6 Adam Self-Reported Outcome Variables Per Topic

Topic Name	t0 level	Target level	Target hours	Progress	Ecology
Education	1	7	2 – 5 hrs/week	+1.5	70%
Psychology	3	10	2 – 5 hrs/week	+0.5	80%
General Knowledge	3	10	1 – 2 hrs/week	+0.5	70%

Generally speaking his dissatisfaction could be attributed to peers, readings and accessibility of *live* courses.

Education: Three main factors could have improved the ‘Education’ ecology, all related to the course. First, the language of the readings was challenging, he would have preferred the reading to be in Arabic. Adding to the language challenge was the fact that not much time was granted for leaving between announcing the reading in the Learning Management System, and its deadline, i.e. the class session. Second, was the quantity of readings; he would have preferred a larger selection of readings. The third factor making up the difference between the 70% and a full 100% was his peers. They were ‘demotivating’ to quote his word. His peers came up, in his perspective, time and again in the class sessions, as very passive in fulfilling their various course requirements.

Psychology: lost its 20% due to peers. “Any ecology that does not have interaction with peers loses 20%” Adam emphasized. He could have checked the peers box by attending the multimedia lectures, around which his ecology revolves, face-to-face,

rather than listened to them as recordings. However, his work conflicted with class sessions, so these courses were temporally inaccessible.

General knowledge: Factors for dissatisfaction were very similar to Psychology; lack of interaction with peers and temporally inaccessible courses. One more factor resulted in the lower satisfaction score, which is the “haphazardness” in the way in which relevant readings (or videos) “reach him”. In psychology he understands the discipline, knows there whereabouts of resources, and reaches out to resources accordingly. In general knowledge it quite the opposite.

Overall: Factors attributing to his overall dissatisfaction are inaccessibility of readings due to prices or language, and videos due to language. Also inaccessibility of courses due to price and due to conditions in some courses on the nationality of attendees.

5.2. Dima’s Learning Ecology

Keywords

Face-to-face / Multiple locations / Social Resources / Family + Peers + Teachers

Background

Dima is married and has a toddler. She is 24 years old and lives in Cairo. She had been involved in volunteer work during the period of the study. Dima dropped out of Med School during her fourth year of study and she joined an Arabic literature

program instead. “The devastating condition of the educational system,” as Dima puts it, led her to dropping out of college altogether.

Topics

Driven by her devastation, Dima set herself on a mission to prove education can be sought from beyond the formal institutional parameters. Parenting a budding child has amplified her interest in the topic ‘Education’. Dima hesitantly joined the ‘Introduction to Education’ course, which although seemed too academic, promised to open some practical doors in the field in which she has been much interested.

Dima was set to practically help youngsters along the off-beaten educational path. Dima had been volunteering with two alternative education communities, and through them she had been exploring ways to fulfil this practical vision. Around current and potential practical engagements with these two communities, Dima furthered her knowledge and skills in ‘Arts for Education,’ her second topic of interest. ‘Arts for Education’ entailed art therapy, using art in education, and using drama in education. These subtopics were not merely convenient topics with accessible resources or opportunities, rather, Dima logged interactions in which she had been actively looking for and exploring such resources and opportunities.

‘Understanding oneself: the seeds, roots and fruits’ is the label Dima chose for her third topic of interest. Although she had considered much of her endeavour into ‘Education’ and ‘Art for Education’ part of her journey of understanding oneself, Dima had a considerable number of learning interactions whose sole purpose was

furthering this specific topic. In the interview Dima reported 'Developing children' and 'Arabic literature' as topics of interest she has not been able to pursue during the period of logging.

Interactions

Between the three pursued topics, Dima logged an average of five interactions per week, dedicating on average 13 hours per week to lifelong learning. Figure 12 below shows the number of interactions per week, along the three topics she logged into the App, over the 9-week duration. Dima started logging a bit later than Adam, precisely on the 12th of November, as she had missed the first session of the course and attended a session re-cap on the 11th along with others who missed first session. Her first loggings were learning interactions taking place within this first week but before her first session. Dima continued logging until late April 2018, however, only the data logged until the week beginning 31st of December 2017 are included.

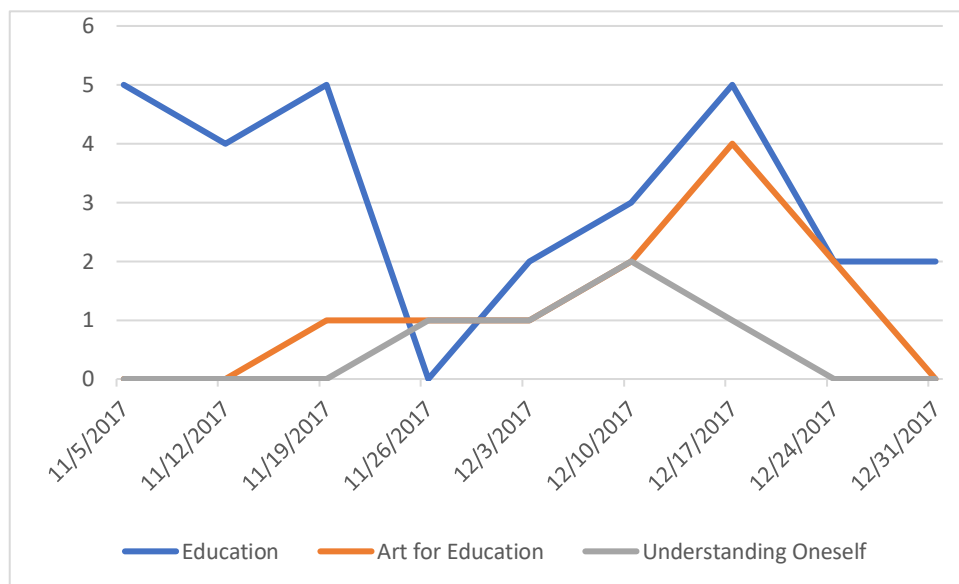


Figure 12 Dima's Number of Interaction Per Topic Per Week

Dima logged a total of 44 interactions, amounting to 110 hours of learning. Figure 13 below (left) shows the breakdown of the interaction, in terms of both number and duration, along the three topics. Figure 13 below(right) shows the number of resources interacted with per topic. 'Education' had 28 interactions, with 17 resources, aggregating 63 hours. 'Art for Education' had 11 interactions with eight different resources, accumulating 31 hours. Understanding oneself had five interactions with four different resources, totalling 16 hours.

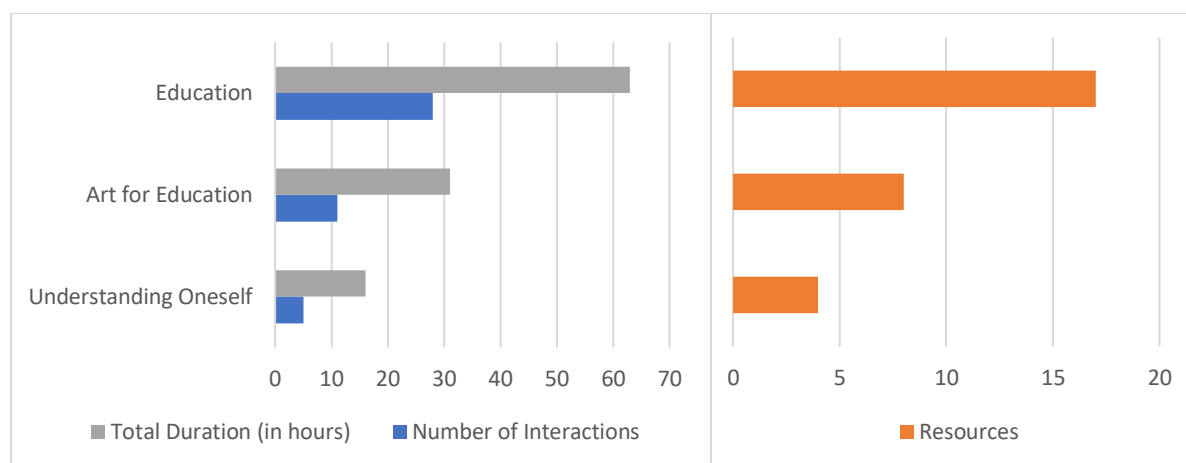


Figure 13 (Left) Dima's Number of Interactions (and hours) Per Topic, (Right) Dima's Number of Resources Per Topic

Resources

Dima pursued advancement in the topic of 'education' largely within the affordances of the 'introduction to education' course. In addition to the material resources availed through the course, Dima engaged with extra-curricular resources, none of which were around the topics of the course, rather they were two book referrals by friends relevant to her wider interest in the topic of Education and she engaged with them as such. Dima cited search engines as resources utilised to find suitable literature for the research project, she succeeded at finding only one resource fulfilling the research project's requirements. Beyond the course instructor, Dima did not engage in any learning interactions with her fellow course participants except within the group assignment. Dima engaged her husband in lots of discussions post readings, sessions and during work on course assignments.

The ecology of Dima's secondary topic, namely 'Arts for Education,' was completely different from that of Adam's secondary topic. As mentioned earlier, 'Arts for

Education' was pursued around volunteering in an alternative education community. The learning ecology was thus largely social. One mentor/instructor was mentioned for using drama in education, and peers participating in some preparatory workshops were cited. Another mentor was cited for using art in education, along with two kids who shared the learning experience. A mentor delivering a taster art therapy session, along with a colleague sharing the experience. This specific colleague, although living in another city, was very much a learning partner engaging in discussions, referring resources, and sharing learning experiences when convenient. Dima's husband was not engaged within the 'Art for Education' topic. The only non-social resources under this topic were three movies, all referred to by the educational drama instructor.

Dima's third topic, 'Understanding oneself', again engaged mostly social resources, along with 'herself' as the main resource. Her husband was another resource, discussions with whom have brought her much insight and understanding. A therapist, with whom Dima had several discussions, was another major resource. Dima attended several group therapy sessions, in which she contributed very little. Nevertheless, she noted that she learned a lot through listening to the group sessions' participants and the therapist's comments.

Contexts

Unlike Adam, Dima's learning was much more spatially distributed. Dima logged learning in 10 unique locations. Her home had the highest number of learning interactions (n= 21). The alternative education community's centre housed 9 of her interactions. Family members homes housed four interactions. Informal learning

centres housed two 'introduction to education' sessions and three group therapy sessions, totalling five interactions. Cafes housed two interactions while a friend's car and a movie theatre housed one interaction each..

Although a large part of her Saturdays were consumed by one big interaction, namely the 'introduction to education' course's weekly sessions, it still had the highest number of interactions. One reason for that is the availability of her husband to help her with childcare responsibilities. Apart from that learning is spread throughout the week and day.

Outcomes

Dima's grade for the course was 88% ranking 7th. As Table 7 below shows, Dima identified her initial level of mastery of the topic Education as a complete novice, with a target to reach a level 5 of 10, 10 denoting Masters level mastery. She intended to put in two to five hours per week. She had actually put in much more time than initially intended, committing slightly less than eight hours of learning per week to the topic. She perceives herself to have progressed 4 points on the 1 to 10 mastery scale. Art for Education had an initial level of mastery, target level of mastery and target hours of learning per week, all similar to the topic Education. And indeed, slightly less than four hours per week were dedicated to the topic, however, the overall self-perceived progress was 1 point on the 10-point scale. Understanding herself had an initial level of mastery of 4 and target level of 8. Dima intended to commit 8 to 12 hours per week to this topic, however, she was able to merely commit two hours per week. She progressed 2 points on the 10-point scale. When asked about her satisfaction with the support provided by the respective topical

ecologies, Education, Art for Education and Understanding oneself scored 20%, 60%, and 50% respectively. When asked about her satisfaction with the support provided on an overall level by her ecology, Dima, scored it 60% satisfactory.

Table 7 Dima Self-Reported Outcome Variables Per Topic

Topic Name	t0 level	Target level	Target hours	Progress	Ecology Satisfaction
<i>Education</i>	1	5	2	12+ hrs/week	20%
<i>Art for Education</i>	1	5	2	1-2 hrs/week	60%
<i>Understanding Oneself</i>	4	8	4	2-5 hrs/week	50%

Generally speaking her satisfaction/dissatisfaction could be attributed to her expectations versus reality, peers and teachers (in her case therapist) and joining 'suitable' structured learning experiences.

Education: Dima's frustration with her 'Education' ecology could very well summarized into one reason: her expectations. The course's approach and demand both were different from her expectations. The supports availed by the 'Intro to Education' course were not very supportive to her, not because they are not supportive in themselves, rather, because she does not appreciate this type of support. "So it is because of me not the ecology" Dima explained. The "academic dimension" of the course (working in a structured way in a group along readings, projects and assignments) is associated in her mind with formal education. And she had not been conscious on enrolment she was choosing these dimensions. Had this been a formal academic experience, she would have been more satisfied.

The course was also *conflictively* demanding. Although Dima had put in the hours, averaging 9 hours every week through her 7-week logging period, she seems to have put them with unexpected and unaccounted hardship. Speaking retrospectively in the interview she said she had been weaning her child at the time and had not yet sent her to day-care services. Despite these family demands, she said that if she had planned it out, deciding consciously that she would be giving more time to 'Education,' she might have been more satisfied. To quote her words, "[unlike 'Arts for Education'] the topic 'Education' was because the course started it, not because I decided to do it".

Art for Education: Dima feels that attending the specific long *course*, which she attended the taster session of during the logging period, would be the main lever to her satisfaction here. The course would be running the following year, and until then she sees nothing advancing her ecology.

Understanding Oneself: Dima had joined a different therapy group (*peers*) after the data logging period, which was much more diverse, outgoing, and expressive than the one she had been attending through the logging period. Had she been evaluating this group's support she would have added 20% to her quoted satisfaction score. Joining the discussion within the group (*peers*) would have further advanced her satisfaction. And changing therapist (*teacher*) would have also improved her satisfaction.

Overall: Dima mostly reiterated consciousness of her decisions as the main factor that would make her more satisfied with her overall ecology.

5.3. Sally's Learning Ecology

Keywords

Impoverished / Few Topics / Digital / Home-based / Material / Readings-centric /

Background

Sally is married and has a toddler. She is 36 years old and lives on the outskirts of Cairo. During the time of the 'Intro to Education' course, she was enrolled in a Ph.D. program in natural science. She had completed both her Bachelor's of Science and Masters of Science degrees with high honours. Sally had teaching experience in a University outside Egypt, before moving back to Egypt.

Topics:

Although Sally identifies "interest" is the reason for pursuing the topic 'Education' in the App, and her application to the 'Intro to Education' course adds 'future' work requirement as a motivation. In her application she writes: "teaching and interacting with kids were some of my passions since I was young". After secondary education she considered studying Education, Paediatrics or Science. Her deliberations and societal influence led her to choosing the latter. After her Masters, she taught undergraduate students, and beyond the realms of formal education she taught Islamic studies in community settings. Going into the future, she wants to have a role in improving education and had joined the online course as an early step on the journey of preparing for such a role.

Psychology was the only other topic she logged on the App, and similar to 'Education', no reason for learning has been indicated. Her specific Ph.D. topic, Paediatrics, and Islamic studies were other topics mentioned in the interview as topics on her attention span during the logging period, however, no interactions were logged on those three topics. Her PhD topic is obviously an academic requirement. Paediatrics a lifelong passion ignited by her parenting obligations and aspiration to socially help her friends and community. Finally, Islamic studies is religiously motivated.

Interactions

Sally logged 10 interactions through the 8-week period, amounting to 21 hours of learning. Only one of those interaction was pursuing 'Psychology', taking a mere 30 minutes. The other 9 interactions, amounting to the remaining 20 hours 30 minutes, were in pursuit of advancement in the topic of 'Education'.

In her reflection statement, Sally expressed "deep admiration for the idea of logging one's learning". And she regrets not being able to record more interactions. She justifies the number of interactions which she perceives as falling short of her aspirations by two things. First, she was too busy to log interactions due to the demands of her toddler child. Second, she had in fact not been able to conduct many interactions, and in many cases had to skim through course required learning materials "in a manner" which she sees "unworthy of being logged as a learning interaction". Evidence to her first justification, my course notes indicate her

attendance in seven out of the eight course gatherings, she logged only five of those. And evidence to her second justification, in the interview she mentioned some sort of interactions with 13 of the course's required resources, whilst on the App only five interactions were logged. In the interview, she described individually all of those not logged in the App as either partially or skim read.

Two out of the three topics mentioned above as on her attention span, however were not logged into the App, namely her PhD Topic and Paediatrics seem to have fallen victim to the same justification. Their interactions, as per the interview, were brief, sporadic and short of what she regards as proper learning interactions.

Resources

Sally pursued advancement in the topic of 'education' exclusively within the affordances of the 'introduction to education' course. She logged a total of six resources under the topic 'education'; the five material resources mentioned above, along with the course instructor. The course instructor was the only social resource mentioned. In the name generator survey Sally indicates she had interactions with two colleagues through the course, one of which has she has also interacted with for the course group assignment. None of those two colleagues were logged as social resources on the App. Maybe again due to the interactions falling short of Sally's definition of a learning interaction.

Sally's short interaction advancing the topic of 'psychology' was with a book that had been referred by a friend. And although the 272-page book could not have been

possibly read in a mere 30-minute session, no other interactions with the book were logged during this logging period. It is important to note that through the interview it seems that the interest in the book is more than the interest in the topic, rather, the topic seems to have been an afterthought.

According to the interview, Sally advances herself in the topic 'Paediatrics' situationally along the life of her young toddler. Whenever a health question arises, due to illness or stumbling upon conflicting opinions, Sally commits to researching the topic elaborately before going on to her Paediatrician. The Paediatrician would then further elaborate and potentially guide her to further resources. Sally would then use her knowledge guiding other parents, in family and friend circles, facing similar questions or concerns. The topic thus is relatively rich with social resources, including her child, the Paediatrician and then friends and family, all of whom are extended lifelong relationships. The material resources on the other hand are less structured, stemming in part from the Google search engine, and entailing in few cases some journal articles.

Sally's toddler had faced one illness during the duration of the course however she believes her learning around this illness does not render itself to the status of a learning interaction. Similarly, Sally had sporadic interactions with her Ph.D. supervisors during the logging period, however, again not learning interactions.

Contexts

Most of Sally's interactions were digital from the confinements of her home. nine of Sally's 10 interactions were digital interactions and the 10th was reading a print-out

of a chapter shared 'digitally' as part of the requirements of the course. Eight of Sally's 10 interactions were at home, and the remaining two were from a family member's 'home'.

The course's sessions and her toddler's sleep defined the temporal dimension of her ecology. Seven of her interactions were in the weekend, five of which are the Saturday course sessions. The remaining two weekend interactions and a Thursday (weekday) interaction were preparing for the course session, going through the required reading or working out the assignment. In her reflection, statement Sally mentions that the existence of specific start and end time for the sessions of the course made them the easiest interaction to occur during the logging period. She added that beyond those time-boxed sessions, "morning time, whilst her toddler was sleeping, allowed for a couple of reading sessions", precisely three if we add the early afternoon interactions (not course sessions) logged into the App. Only two of the interactions took place in the evening, one of which (the Thursday interaction mentioned earlier) during a family visit.

Outcomes

As Table 8 below shows, Sally is pretty unsatisfied with the two reportedly inactive topical ecologies, supporting her PhD topic and Paediatrics, giving them ecological satisfaction scores of 25% and 15% respectively. Sally provided no satisfaction score for the 'psychology' ecology. No progress has been reported along those three topics. The ecology supporting the topic of 'education' on the other hand receives a healthy score of 75%. Sally started off with a level of mastery of 5 out of 10, received a grade of 92% in the course ranking 3rd, and progressing 2 marks to a 7.

Generally, she believed her ecology provided a much needed framework on the educational studies landscape. And she came out of a new topic of interest, namely ‘sociology of education’.

Table 8 Sally Self-Reported Outcome Variables Per Topic

Topic Name	t0 level	Target level	Target hours	Progress	Ecology
Education	5	10	5 – 8 hrs/week	2	75%
Psychology	3	8	1 – 2 hrs/week	-	-
PhD Topic	3	5	-	-	25%
General Paediatrics	4	6	-	-	15%
Islamic Studies	7	8	-	-	50%

Generally, her satisfaction/dissatisfaction could be attributed to her ‘dedicated’ mentors, knowledge of suitable references, connection to peers along her learning journeys and support with her childcare responsibilities,

Education: Sally mentions that she prefers face-to-face courses over online courses attended from home, as they allow more focus, easier communication with the instructor, and relationship with course colleagues. Yet, acknowledging the geographical distance between her residence and the centre of the city, where most such courses take place, and her childcare obligations, she suffices (and to an extent appreciates) the ecology afforded by the digital format. A more favourable home environment, maybe with her toddler receiving some professional day-care, which was not the case during the logging period would have made her ecology much better. Furthermore, easier readings, in terms of language, would have also made her ecology much better.

Ph.D. Topic: Sally attributed part of her dissatisfaction to her supervisors. She complained about very scant communication, direction, and source recommendations. She also felt having peers to share her journey would improve her satisfaction with the ecology. Finally, physically going to the University would also elevate her satisfaction. Had she had some support with childcare and with her other family obligations, she might have been able to go to the university.

General Paediatrics: Having a 'dedicated' mentor instead of relying on the random interactions with her child's doctor, who is not necessarily keen on 'her' learning. Also, a better understanding of the references (*readings*) would improve her satisfaction.

Islamic Studies: Having an understanding of the references and access to peers through WhatsApp groups mark the difference between the 'General Paediatrics' ecology and the 'Islamic Studies' ecology. This leaves having dedicated mentors and the childcare demands as the main sources of dissatisfaction.

Overall: Sally reiterated her needs for peers and mentors. Both encourage and follow-up pushing forth the learning interactions she yearns for.

5.4. Farrah's Learning Ecology

Keywords

Many topics / Face-to-Face / Home + Informal Learning Centres / Social + Material

Background

Farrah is in her forties. She is married and has two daughters aged 20 and 16. She has a Bachelor of Arts degree in French language, and had taken up relevant employment teaching French in schools at an earlier point post her ungraduated education. She had also taken up multiple freelance roles in training and writing. At the time of the course she was neither in full-time or part-time employment or formal education.

Topics

Farrah logged six distinct topics into the App; Education, History, Self-Development, Spiritual Development, Voice-over narration in Modern Standard Arabic, and the Quran. In the App, she designated all the topics as interest-based pursuits, but the Voice-Over topic, indicated as a work requirement. In her reflection statement, she highlights religious motivation as the general driver behind her lifelong learning pursuits.

From amongst the six topics identified, the Quran, Spiritual Development and Self-Development seem the most obvious religiously motivated topics. Her reflection statement emphasizes this religious motivation for learning the Quran, however, gives no mention whatsoever to spiritual and general self-development.

Voice-over falls at the intersect of her passions for languages, reading and narration. She emphasizes in her reflection statement that she learned voice-over to use it

practically narrating articles for different voice narration platforms, helping people make use of their in-transit time. This desire to help people is religiously motivated.

Although 'Education' was indicated as an interest-based pursuit in the App, as mentioned above, taking her statements in the application form and reflection statements reveals it is borderline between interest and work requirement. Applying to the course, Farrah emphasized her multiple experiences in teaching and emphasizes learning about 'Education' would further tone her practice. In her reflection statements, she maintained this practical motivation, yet emphasized she is pursuing this topic for "myself".

Interactions

Between the six topics pursued, Farrah logged a median of 3 interactions per week, dedicating on average six hours per week to lifelong learning. Figure 14 below shows the number of interactions per week, along the six topics she logged into the App, over the 9-week duration. Farrah's first logged interaction was the first session of the 'Intro to education' online course on the 4th of November. Farrah continued logging until the first week of January 2018, accordingly and as in the case of Dima the data logged until the week beginning 31st of December are included. Throughout the logging duration, Farrah used the comments section in the interaction log screens extensively with dotting down reflective comments.

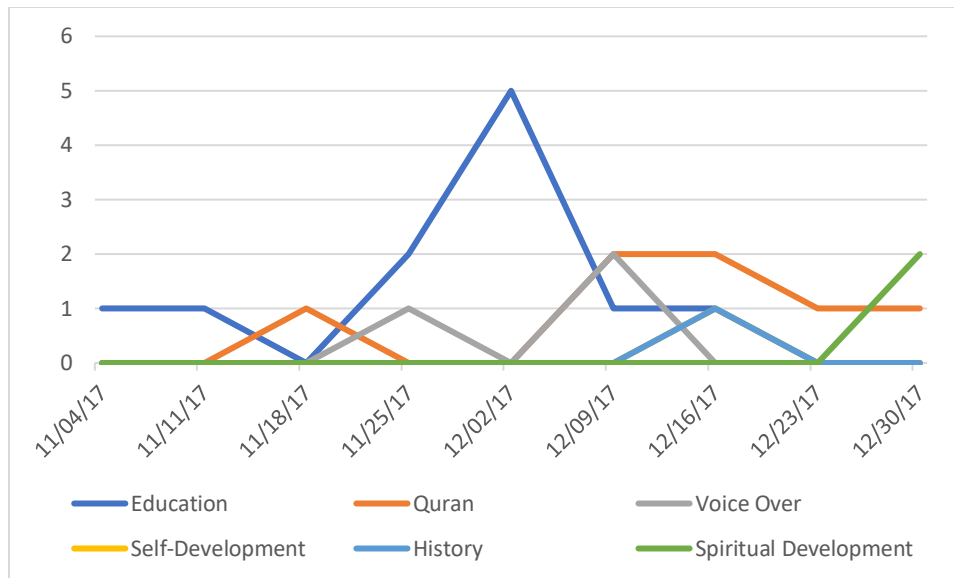


Figure 14 Farrah's Number of Interaction Per Topic Per Week

Farrah logged a total of 25 interactions, amounting to a total of 55 hours of learning. Figure 15 below (left) shows the breakdown of the interaction, in terms of both number and duration, along the six topics. 'Education' entailed 11 interactions, aggregating 21 hours. 'Quran' had 7 interactions accumulating 22 hours of learning. 'Voice-over' had 3 interactions totalling a mere 4 hours. The three other topics, namely 'spiritual development' (2 interactions, 2.5 hours), 'history' (1 interaction, 1 hour), and 'self-development' (1 interaction, 5 hours) were dismissed in her reflection. Farrah mentions as one takeaway from her logging experience that she should not be pursuing more than two topics at any given time period to be able to give them their due time and attention.

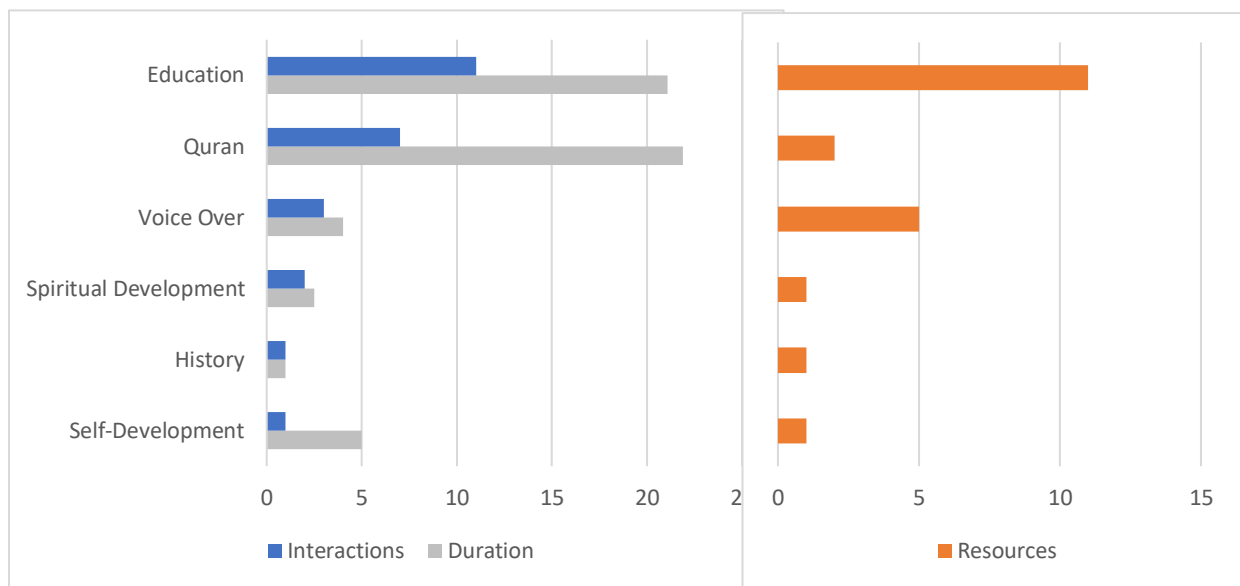


Figure 15 (Left) Farrah's Number of Interaction (and hours) Per Topic, (Right) Farrah's Number of Resources Per Topic

Resources

Farrah sought advancement in the topic of 'Education' almost exclusively within the affordances of the 'Intro to Education' online course. Logging the interactions furthering the topic of education in the App, Farrah abstracted the resource under two descriptions 'article' and 'article with friends'. Her elaborate comments on the interactions together with the interview allowed re-coding these resource descriptions for the various interactions bringing the total resources to 11 resources as per Figure 15 (right) above. Eight of these 11 resources were textual material learning resources. The remaining three were social; the course instructor, a peer and a group of colleagues.

Five out of the 11 interactions furthering the topic of education entailed multiple resources. Writing her educational philosophy Farrah utilised five resources, one of

which, a book, was not part of the assigned course readings. Working to understand one of the required reading requirements, Farrah joined a group of colleagues to translate sections and read the whole article off each other translations, this took place over two of her interactions, and entailed the designated article and colleagues. Two out of the five sessions logged included the instructor, reading material discussed in the session, and the “colleagues”.

Similar to the ‘Education’ topic, Farrah sought advancement in the topic of ‘Quran’ solely within the affordances of a structured experience. And similar to the ‘Education’ topic, the resources supporting the Quran learning ecology seem to be underrepresented by the App’s sample. A teacher and the holy book itself were the only two resources recorded furthering the ‘Quran’ topic on the App. Between the reflection statement and the interview, Farrah added multimedia lectures and three different ‘types’ of books as further resources making up this topical learning ecology.

Similar to the ‘Education’ and ‘Quran’ topics, Farrah pursued the topic of ‘voice-over’ through a structured training program. Unlike them however, the voice-over ecology, was well represented on the App, boasting five different resources. This training program had been recommended by someone she follows on the Facebook. Two of five resources recorded were social; the vocal narration trainer and the studio technician. The remaining three were material including a narration platform through which she listens to narrated articles for practice, and an article and microphone for practical narration training in the studio.

The three dismissed topics were all not supported by extended structured learning experiences. Two of them however, namely spiritual and self-development, still have traces of the seeking of pre-prepared structure. The self-development ecology was supported by one 1-day workshop delivered by a trainer, having been advertised on Facebook. The spiritual development was supported by audio-recorded lectures published on Soundcloud. She had originally intended to attend these lectures live, however, was pre-occupied at the time, so decided to listen to them afterwards. The history ecology was supported by a stumbled upon historical documentary.

Contexts

Farrah logged learning in five different locations. Three of those locations fall under the category of 'informal learning centre' each part of one of the three extended structured learning experiences supporting the three active topics. The 'Intro to Education' course had its informal learning centre for the two optional face-to-face sessions. The 'Quran' program had its academy. And the 'voice-over' training program's practical sessions took place in the studio. Taken together, the 'informal learning centres' category locational makes up 28% of Farrah's ecology. The majority of Farrah's interactions (68%) took place from home. Home supported all of Farrah's topics except self-development. A café hosted only one of Farrah's interactions.

Farrah distributed her interactions evenly between the weekends and weekdays. She also distributed her interactions evenly between morning, evening and noon, conducting absolutely no interactions at night.

Outcomes

Farrah scored 73% in the 'Intro to Education' course. As shown in Table 9 below, Farrah was extremely satisfied by the support provided by the three active learning ecologies, assigning scores of 90%, 90% and 95% to 'Education,' 'Quran' and 'Voice-over' learning ecologies respectively. According to her, the three other topics were too ad hoc to consider a learning ecology for them. Farrah also self-reportedly progressed along those three topics, moving from 5 to 7, 5 to 6 and 3 to 8 along them respectively. Despite having not progressed along the other 3 topics, on an overall level Farrah expressed she is 95% satisfied with her ecology.

Table 9 Farrah Self-Reported Outcome Variables Per Topic

Topic Name	t0 level	Target level	Target hours	Progress	Ecology
<i>Education</i>	5	8	2 – 5 hrs/week	+2	90%
<i>Quran</i>	5	8	5 – 8 hrs/week	+1	90%
<i>Voice Over</i>	3	7	NA	+5	95%
<i>Self-Development</i>	6	9	1 – 2 hrs/week	-	
<i>History</i>	2	4	1 – 2 hrs/week	-	
<i>Spiritual Development</i>	2	6	2 – 5 hrs/week	-	

Generally, her dissatisfaction could be attributed to 'features' of the informal learning centres, resources allocation over time, time allocation along topics and adherence

to time-slots scheduled. Family support has been highlighted positively as a primary lever for satisfaction.

Education: Farrah believes that the informal learning centre chosen for the two face-to-face session was not very comfortable. Furthermore, the course was a bit “overloaded” with resources. This overload, however, is relative to time. Had the course been extended over a longer period, it would have been optimal.

Voice-Over: Its ecology could have been satisfying had its informal centres been geographically closer to her residence.

Quran: She would have been more satisfied with this ecology if she had adhered more to times she scheduled for personal studying.

Overall: Dedicating more time to learning more generally. And properly planning out the allocation of time between the different topics as needed. Both of which she believes are personal rather than ecological factors. Farrah sent an email after the interview to acknowledge and appreciate her family’s (spouse and offspring) support of her learning.

5.5. Comparing their 'Education' ecologies

I start here by comparatively analysing the four portrayed learners' 'Education' topical learning ecologies. Considering that the four learners pursued the topic 'Education' largely within the affordances of the 'Intro to Education' course, these 'Education' ecology comparisons are especially insightful on two levels. The first level is revealing how much the App is capable of capturing the important information about the ecology. Data concerning the interaction in the 'Intro to Education' course has been triangulated by three data collection methods: field notes by the researcher/instructor, course submissions including the application forms and reflection statements, the name generator survey and the interview including detailed questions pertaining each of the course required and optional readings. Comparing the image of the 'Education' ecologies painted by the App to that augmented by the other data collection methods reveals discrepancies, if any, and helps appraise the App was a data collection tool.

The second level at which comparing 'Education' ecologies is especially insightful is revealing learners' ecological preferences, if any. Adam, Dima, Sally and Farrah, all had their entire respective cohorts and the course instructor as potentials for social interactions, they had an equal number of group-project colleagues as even more high-potential social interactions, and they had the exact same required and optional readings, and videos, as potential for material interactions. Yet, the four learners took certain micro-decisions that resulted in quantitatively and categorically different 'Education' learning ecologies.

Building on the portraits presented above, the paragraphs below focus on the quantitative and categorical differences between the learning ecologies.

5.5.1. Topics

All of the four learners indicated interest/lifelong learning as the reason for pursuing the topic 'Education' on the App. Their applications to the 'Intro to Education' course and their reflection statements gave more depth to this. Adam is seemingly the only one to be pursuing the topic education out of pure interest or service to lifelong learning purposes, planning to simply use his expanded knowledge to make more informed decisions concerning his children's education. Dima, Sally and Farah on the other hand seem to have traces of learning to satisfy work requirements, taking the word "requirements" more informally. Dima was engaged in volunteer teaching activities. Sally and Farrah explicated their intention to put this promised new knowledge and skills to use in educational settings.

5.5.2. Interactions

The level of activity varied among the four learners. In fact, the choice of these specific four lifelong learners from amongst the sample of 24 research participants has been partially motivated by these varying levels of activity. On the high side of the activity continuum, Adam and Dima dedicated a similar number of interactions to 'Education', 34 and 28 respectively, especially taking into consideration that Adam has recorded on the App seven out of the eight course sessions actually attended

although Dima has recorded only two out of the seven she attended. From a relative perspective though, Dima dedicated a larger percentage of her overall learning to 'Education', 63%, compared to Adam, 56%, again disregarding those interactions not actually recorded on the App.

On the lower side of the activity continuum, Farrah and Sally dedicated a similar number of interactions to 'Education' 11 and nine respectively, however amounting to drastically different percentages of overall learning. Farrah dedicated the lowest percentage of overall learning to 'Education', precisely 44% of her total 25 interactions, Whilst, Sally dedicated 90% of her total 10 interactions to 'Education'. Accounting for unlogged interactions does not change the significant higher relative dedication to the topic of learning as both have recorded less sessions than actually attended; Sally recorded five out of seven and Farah recorded five out of eight.

Comparing the resources logged on the App to those captured, as interacted with, by the other data collection methods, exacerbates this discrepancy between the actual number of interactions and those logged by the App. Yet, the question remains, considering the App has been intended from the outset to collect a sample of learning interactions, if the sample of interactions collected is representative enough of the topical and overall learning ecologies studied. The next two subsections, concerning resources and contexts, aim to present more findings concerning the discrepancy and the representativeness of the data collected through the App, along with highlighting the differences between the participants within the affordances of the common 'Intro to Education' course.

5.5.3. Resources

The four participants had interacted with resources, as per the interviews and name generator survey, which they have not logged into the App. Table 10 below shows the number of resources logged into the App and those captured through other data collection methods. In both cases the resources are broken down into material and social. For other data collection methods, two quantifications for material resources are highlighted; one including those resources which have been skimmed or partially read/viewed by the respective learner, and another exclusive to material resources completed. For the App data, the researcher added a quantification for material resources to distinguish those resources which are part of the course readings. As noticed the social resources vary little between the App's data and other data, for all participants but Sally, who has mentioned interacting with a peer in the interview, however, excluded her in App, and Farah who logged into the App a collective labelled "colleagues" not obvious in the interviews as a social resource. With material resources the picture is different. Comparing the assigned materials captured by the App to those captured by the interview (as the interviews focused on assigned materials only), we have the App data lacking for all participants, if compared with the total including skimmed, and for all participants except Sally, if compared with finished materials only.

Table 10 Number of Resources Captured Through App Versus Other Methods (Adam, Dima, Sally, Farrah)

Source	Resources	Adam	Dima	Sally	Farrah
Other	Social	1	5	2	3
	Material (Finished only)	10	10	4	10
	Material (including skimmed)	12	13	12	11
	All Resources	13	18	14	14
	Sociability Ratio	8%	28%	14%	21%
App	Social	1	5	1	3
	Material (Finished only)	12	12	6	8
	Material (course readings)	5	7	6	7
	All Resources	13	17	7	11
	Sociability Ratio	8%	29%	14%	27%

Considering that the App was intended as a sampling method, unable to capture the full picture, similar to other techniques, however, capable of capturing what other methods cannot, we find that the total resources are similar for all participants but Sally. The reason for this catchup by the App's data is its capture of those material resources that were not part of the course readings, which Adam, Dima and Farrah utilised. Adam was less comfortable with English language readings, and thus consistently sought alternative readings to the ones assigned, in Arabic. "And although that having not read some articles did affect my ability to discuss them during the course session sometimes," Adam wrote in his reflection statement, "[these alternative readings] amplified in my opinion the benefit of listening to the discussion being conducted". Farrah used one external resource whilst writing her educational philosophy assignment. And Dima interacted with two external resource, both books, referred by friends feeding her wider interest in education. Sally, on the other hand, still have her total resource loggings on the App lacking. And, as mentioned earlier in her case description, she explicated the reason she did not log

some of the resources. She felt her interaction with them was “not worth of being [logged as] a ‘learning’ interaction”.

Despite Sally’s conception affecting the absolute count of resource, the App has been reliable in capturing the relative attributes of the resources in the ecology. Sociability, the percentage of social resources from the total resources, as an example of a relative attribute, is pretty similar for all the four participants when calculated for the App data and when calculated for the other sources data.

In general, in these ‘Education’ ecologies, more material resources were logged than social resources, rendering sociability percentages ranging from 8% to 28%. These low percentages are quite expected considering the course design was heavy on readings and videos, and only one out of four required course submissions required group work. Adam represents the lowest sociability among the four learners with 8%. Sally represents medium sociability with 14%. And Dima and Farrah represent higher sociability with 21% and 28% respectively.

On an overall level, taking stock of resources from within or without the course references, the composition of resources advancing the topic education for the four portrayed learners varied little. They’ve all interacted with, and logged, the course instructor, course readings and assignments. None logged videoing the required multimedia resources. And Adam exclusively logged multimedia resource, nonetheless external to the course references. Both Farrah and Dima, relatively more social, logged interacting with at least one peer. Dima, singled out, engaging her husband in multiple interactions discussing readings, session contents and

assignments. And Farrah, singled out among those four participants, getting involved in the collaborative translation effort undertaken by her colleagues.

5.5.4. Context

On the locational front, the App data captures almost the learning locations captured otherwise. Only Farrah missed logging a location revealed by other data; namely in the informal learning centre in which the two face-to-face course sessions were conducted, both of which she attended. Adam and Dima, both of whom also physically attended, have managed to log at least one interaction in this informal learning centre. Dima and Sally both had at least one interaction at a family's home. Dima and Sally share interacting in cafés. Dima and Adam share learning in-transit. And Adam singles out interacting at work.

On an overall level, Dima has the most locational spread learning, logging eight different locations. Adam follows with four locations. Farrah and Sally trail with two each, one of which, precisely the home, much more central, accounting for 90% and 77% of their learning interactions respectively. Adam and Dima also have the majority of their interactions at home; 67% and 61% respectively. Adam has a significant portion in-transit, 26%. And Dima has 40% of her learning distributed between informal learning spaces and family/friend's home, 14% each, and two interactions in cafés and one in-transit, in a friend's car.

On the temporal front, in the interviews participants were incapable of recalling temporal details matching or close to those captured by the App. The time details

logged have been admittedly not “100% accurate,” to quote a few participants, yet they could not recall to any comparable level of accuracy, at the time of the interview, the temporal details associated with their learning interactions. In their reflection statements they noted temporal highlights, like Sally mentioning she is capable of doing more learning in the morning “when [her] child is asleep,” and Adam mentioning that he did a big portion of his learning early in the morning, on his way to work, and in the late afternoon / early evening, on his way back. These temporal highlights were largely validated by the App data.

On an overall level, Dima had the most temporally spread learning. 32% of Dima’s interactions were at night, 18% were in the morning, 28% noon, and 21% at night. Adam, Farrah and Sally had most of their learning between noon and evening, with 82%, 91%, and 88% respectively. Farrah and Sally did not log any interactions at night, and in fact 54% and 67% of their interactions respectively were around noon. These higher noon interactions however are due to the fact that their online course sessions were at noon and these made up a large chunk of their total interactions. The same could be said explaining their 81% and 78% weekend interactions, respectively; the course sessions were on Saturdays, and they made up the greater chunk of their fewer learning. Adam and Dima, on the other hand, balanced their learning between the weekdays and weekends with around 50% each.

Adam and Sally’s ecologies were almost exclusively digital. Adam logged 100% of his interactions as digital, having missing logging the face-to-face course sessions he attended. And Sally logged 89% of her interactions as digital, the single non-digital one being reading a print-out of a digitally shared course required reading.

Farrah and Dima similarly had two thirds of their interactions digitally. Both participated in structured learning experiences taking place physically in informal learning centres.

5.5.5. Outcomes

Despite the lower number of interactions, Sally got the highest grade (92%) in the course amongst the portrayed group. She had originally intended to dedicate the greatest amount of time per week to the course (5 – 8 hours), as per her logging in the App, and despite not having dedicated the time she intended (2.5 hours per week according to App loggings) she almost exclusively dedicated her learning time to 'Education', and gave its learning ecology a satisfaction score of 75%. However, her exclusive dedication might partially explain the 40% satisfaction assigned to the overall ecology. Dima, intended to dedicate the same amount of time per week as Adam and Farah (2 to 5 hours) to 'Education', yet she ended up dedicating 7 hours (Adam and Farrah dedicated 5 and 2.5 hours respectively). This increase of time might also partially explain her low satisfaction with the 'Education' ecology, standing at 20%, compared to satisfaction scores of 70% and 95% by Adam and Farrah respectively. Farrah's higher satisfaction score is despite a much lower course grade, 73%, as opposed to Dima's 87%. Dima's satisfaction with her overall ecology, 60% is higher than that with her 'Education' ecology.

Similar to Sally, Dima cited obligations to her child, as an ecological dissatisfaction factor. Concurring with Sally's behaviour, she mentioned that allocating more time to the topic 'Education' as accentuated in the 'Intro to Education' course as a factor that would have raised her satisfaction with the 'Education' ecology. Farrah, on the other

hand, cited the older age of her children, and the less time demands they pose on her as a positive element in her ecology. Adam and Sally both would have rated their respective 'Education' ecologies had the course material resources been in easier English, or better off in Arabic.

5.6. Comparing the ecologies beyond the 'Education' topic

5.6.1. Comparing other topical ecologies

Beyond sharing a topical ecology supporting 'Education', the four learners aggregated a total of 10 topical ecologies on the App. Adam and Dima had two other topics each. Farrah had five other topics. Sally had three other topics, as per the interview, only one of which made its way to the App. Nine out of these 10 logged topics were motivated by interest/lifelong learning. Only Farrah had one topic indicated on the App to have been pursued for work requirement, namely "Vocal narration skills". Sally's two unlogged topics arguably had at least one interaction each during the logging period, however, these interactions fell short of Sally's conception of a worthy learning interaction.

Four of the topics pursued by the group were arguably inactive during the logging period with one or two interactions at most pursuing them. Farrah logged one interaction for two topics, 'Self-Development' and 'History' and two interactions furthering 'spiritual development'. Sally logged one interaction pursuing 'Psychology'. Deeper analysis, as per the case descriptions above, lead to the conviction that Farrah's 'History' and Sally's 'Psychology' were afterthoughts to the choice, in case

of Sally, or stumbling upon the resource in case of Farrah. Adam's 'general knowledge' also seems to have re-appropriated resources originally intended for other purposes, yet Adam with four interactions pursuing this topic seems much more dogmatic at its pursuit. Farrah's 'self-development' was triggered by an opportunity, a workshop advertised on Facebook on an interesting topic which arguably falls under 'self-development'. Similarly, Farrah's 'spiritual development' was triggered by a missed opportunity to attend two lectures on the topic. Farrah's 'Voice-over' topic, although pursued by a mere three interactions, could not be regarded as an inactive, accidental topic, as she had five resources furthering this topic, unlike the case of the four other inactive topical ecologies, supported by one resource each.

Beyond this resource singularity, these four less active ecologies were expectedly very absolute in terms of sociability, digitality, location and time. One cannot achieve much diversity with one or two interactions. Five out of the remaining six were absolute in digitality, either 100% digital or 100% non-digital. Three out of the six were absolute in sociability, either 100% social or 100% material. Five out of six spread over home and one other location, the sixth, Dima's, added a third.

Temporally, the interactions in four out of the six ecologies took place almost exclusively on weekdays. More precise temporal details, such as day of week and time of day, along these 6 active ecologies stand pretty diverse. Table 11 below shows the 10 topics, along with their sociability, digitality, locational centrality and temporal centrality.

Table 11 Comparison of Non-Education Topics (Adam, Dima, Sally, Farrah)

Topic	Psychology	General Knowledge	Arts therapy for education	Understanding Oneself	Quran	Voice Over	Spiritual Development	Self-Development	History	Psychology
Leamer	Adam	Adam	Dima	Dima	Farrah	Farrah	Farrah	Farrah	Farrah	Sally
Sociability	Absolutely material	Absolutely material	66% Social	Absolutely social	50% Social	40% Social	Absolutely Material	Absolutely Social	Absolutely Material	Absolutely Material
Digitality	Absolutely digital	Absolutely digital	Only 27% digital	Absolutely non-digital	Absolutely non-digital	Absolutely non-digital	Absolutely digital	Absolutely non-digital	Absolutely digital	Absolutely digital
Locations	Home + In-transit	Home + In transit	Home + 2 locations	Home + Informal learning centre	Home + Informal Learning Centre	Home + Informal Learning Centre	Home	Informal Learning Centre	Home	Home
Temporal	All on Weekdays	Mostly Weekdays	Mixed	All Weekdays	Mostly weekdays	All Weekdays	Weekday	Weekend	Weekend	Weekday

The ecological preferences observed in the 'Education' ecology, can be observed in the other topical ecologies, as per the table above. As shown Adam, across his two active, and Sally, through her less active Psychology ecology, have retained the three directions of low sociability of resources, high digitality and centrality around home, and in-transit in the case of Adam. Furthermore, Adam continues his focus on multimedia resource. Dima and Farrah maintain their focus on social resources across their non-education topical ecologies. However, Farrah failed to interact physically and socially for the 'spiritual development' topic and ended up with a digital, material interaction. Also, her accidental ecology for 'History' included a single material resource. Dima's husband contributed to her learning beyond the 'Education' ecology and she considered peers important resources in the other topical ecologies too. Dima and Farrah also maintained their bias towards non-digital across their active ecologies. Dima maintained the diversity of locations, logging three locations, for her 'understanding oneself' ecology. Farrah maintained her informal learning centre support to home through both her 'Quran' and 'Voice-over learning ecologies.

5.6.2. Comparing the overall ecologies

Parting the topical lens and taking on an overall one, the four learners' maintain their respective ecological signatures. Dima and Farrah maintain their social resource bias, with 46% and 28% sociability percentages, respectively, both of which seem substantive considering the weight of the 'Education' ecology in their overall ecology and its material bias highlighted earlier in section 4.3.3. Sally and Adam, on the other hand, maintain their material resource bias, with 14% and 5% respectively. Sally and Adam also share a digital preference with 90% and 100% digital interactions respectively. Dima and Sally, represent non-digital bias with 50% and 40% digital interactions respectively, which is again significant considering the 'Education' ecology was largely digital, afforded by an online course. In terms of specific resource types, Adam stands out with 34% of his resources being multimedia resources (compared to 14%, 10% and 0%), and Dima stands out through involving a family member. Locationally, Dima stands out spreading her learning over 10 different locations, Adam logging 35% of his interactions in-transit, and Dima and Farrah logging 20% and 34% of their learning in informal learning centres. Sally stands out dedicating 90% of her limited learning interaction to a single topic. And Farrah stands out by attempting too many topics, and ending up with significant activity in only half of them.

Table 12 below captures the main quantitative metrics used thus in the description and comparison of the four learners' overall learning ecologies. It starts by comparing the number of interactions along the four learners. It then moves on to showing the number of topics pursued for each of the learners, and comparing that

with the number of topics actively pursued. The third row shows the number of resources per topic. The fourth shows the sociability ratio showing the composition of those resources. The table then moves to showing the percentage of learning in two of the frequently occurring locational categories. Temporally it shows the percentage in the weekends, along with the percentage in each of the four major periods of the day.

Table 12 Comparing Overall Ecologies (Adam, Dima, Farrah, Sally)

Domain	Metrics	Adam	Dima	Farrah	Sally
Topics	Number of Topics	3	3	6	2
	Number of Active Topics	3	3	3	1
Resources	Total number of resources	19	29	21	7
	Social Resources as % of Total	5%	46%	28%	14%
	Number of Teachers	1	4	4	2
	Family inclusion	No	Yes	No	No
	Engagement with Peers	No	Yes	Yes	No
	Readings as % of Total	42%	31%	42%	76%
	Multimedia as % of Total	37%	10%	14%	0%
Contexts	% digital interactions	90%	50%	40%	100%
	Number of different locations	4	10	5	2
	% of learning at home	47%	47%	68%	80%
	% of learning in-transit	50%	1(2%)	0%	0%
	% of learning in weekends	28%	39%	48%	70%
	% of learning in mornings	30%	25%	32%	10%
	% of learning in afternoon	22%	34%	36%	70%
	% of learning in evening	40%	18%	32%	20%
	% of learning at night	8%	23%	0%	0%

Reflecting upon these metrics, side by side, in light of the thick descriptions and comparisons presented in this chapter shows how a few quantitative metrics can capture the bigger picture observed for each of the four learners. The next chapters build on this quantitative picture, comparing these, and more metrics across the

wider sample. It will describe and analyse the variance observed along each of the ecological parameters, across the topical and overall ecological levels discussed thus far in this chapter. As such it will follow on investigating some of the insights presented in this chapter (and summarised below).

5.7. Summary

This chapter showcased the conceptual framework applied to understanding and analysing the cases of four of the learners who have participated in this research study. The conceptual framework, in its multiple iterations, had a bi-directional relationship with the case analyses and comparisons; it has helped gain significant insight into learners' cases, and the cases helped advance the theoretical framework. The chapter has focused on presenting the significant insights into the learners' cases and into learning ecologies of lifelong learners as informed by those cases. Its feedback into the framework has been incorporated into its last iteration as presented in Chapter 3. And the conceptual developments will be briefly reflected upon in the conclusion of this thesis.

The event-contingent recording (ECR) approach to data collection, espoused by the App, did not capture the entirety of the topics pursued, resources interacted with, or the learning interactions conducted, as designed and expected. However, the data it collected painted a very similar picture to that inferred through triangulation, in addition various details that would not have been captured had the data collection relied solely on recall.

The four learners' ecologies were all interested in, and in pursuit of different level of mastery in, multiple topics, mostly driven by interest and practical need. Beyond these two common attributes the participants varied on almost all dimensions. The number of topics pursued ranged from 2 to 6, the number of interactions for each of those topics ranged from 1 to 34, and the number of resources interacted with per topic ranged from 1 to 18.

Three findings in this chapter build towards an understanding of how learning ecologies of lifelong learners develop. (1) Although learners are interested in several topics simultaneously, they consciously and unconsciously manage their activity levels across these topics over time. (2) The images of the topical learning ecologies painted by the App's data showed them as relatively homogeneous in their ecological makeup, compared to the overall ecologies they build up into. (3) Furthermore, their makeup on a learner level implies some form of ecological signature, in which the learner seems to exhibit the same ecological preferences across the various pursued topics. These ecological signatures partially explain the difference in the 'Education' ecologies among the four learners despite the fact that all the learners pursued the topic largely within the affordances of the same 'Intro to Education' online course. Furthermore, these signatures explain how the same preferences are exhibited in the other active topical ecologies.

One major theme has emerged time and again throughout the chapter contributing towards an understanding of the relationship between the ecology and its outcomes: the discrepancies between expectations (of oneself or other things or people) and reality. This theme captures, among other things, Adam's frustrations with his

colleagues in the online course, Dima's frustration with the 'Education' topics ecology more broadly and Sally's frustration with her 'Education' ecology despite achieving the highest grade in the class.

Beyond this relationship between the outcome variables and the metrics capturing the ecological parameters beget quantitative analysis, to which chapter 6 will be dedicated. Chapter 7 will also follow-on, at length, the qualitative analysis of the factors mentioned in the interviews contributing towards satisfaction or dissatisfaction with the respective ecologies. The four sections presented here, on this matter, towards the end of each of the case studies builds the foundations of the qualitative analysis presented thereafter.

6. Quantifying Ecologies

This chapter serves three purposes. First, it helps elaborate and operationalise the framework presented in this thesis. The four narratives presented and analysed along the thesis' framework provide powerful examples of learning ecologies of lifelong learners and how they support the respective learners' learning objectives. Beyond narrative, quantitative measures allow a broader examination of the sample as a whole. These quantitative measures allow for a better contextualisation and understanding of the four portrayed ecologies, which in turn allows an understanding of what a typical learning ecology within the sample looks like. A major desired outcome of academic deliberation is agreeing on measures that capture the essence of a phenomenon and allow for quantitative, reproducible, and comparable studies. As such throughout the chapter a central objective will be presenting those quantitative measures and evaluating their merit, capturing the essence of the ecological phenomenon. This quantitative analysis endeavour will entail mostly univariant and descriptive statistics along with strands of qualitative evidence to further support and elaborate the analysis. More than 50 metrics have been explored covering both the ecological elements and outcomes of a learning ecology.

Second, identifying ecological parameters and metrics, this chapter lays the foundation for the upcoming chapter reporting on the relationship between ecological parameters and outcome variables. Unlike case study analysis, these quantitative measures help us draw on the sample's 24 overall learning ecologies, and their associated 121 topical learning ecologies, in exploring the relationship between the ecological varieties and the ecological outcomes.

Third, this chapter further investigates the two findings reported in the last chapter concerning the development of ecologies. The chapter is structured around the main components of learning ecologies, as stipulated by the proposed framework.

Throughout the resources and contexts section analysis will compare topical realities to overall ones, investigating the homogeneity finding. Towards the end of each of these two sections, ecological signatures associated with their respective components will be explored, investigating the ecological signature finding. A fourth section presents a summary of the ecological parameters and metrics explored. And a final section presents a summary of the findings of the chapter.

6.1. Topics and Topical Ecologies

One key feature of the framework proposed in this thesis is the distinction between the overall learning ecology of a lifelong learner and its constituent parts, namely the topical ecologies. The case studies and their comparative analysis showed how the number of topics pursued varies from one person to another, and how the topics actively pursued at a specific point in time are sometimes a subset of the topics a learner has committed, or aspires, to learn. Regarding the latter distinction, it is important to note that the learning ecology as defined in this research only entails the topics actively pursued.

Analysis of learning ecologies in this thesis always takes place on two levels: the topical level and the overall level. In two of the sub-sections below, some caveats concerning the level of activity in topical ecologies and overall ecologies will be laid

down as they will be the basis of the analysis in the sections on resources and contexts. A third subsection, under the heading ‘topical dynamism,’ reports the findings from the qualitative analysis of the participants’ comments in the interviews on their level of activity across the topics.

6.1.1. Topical Ecologies

Across the study sample, 121 topics have been actively pursued, albeit with different levels of “activity”. Taking the number of interactions to denote activity, Figure 16 below shows the level of activity per topic for the total number of topics logged by all the research participants ($n = 121$). It is clear from the right-skewed nature of the frequency polygon that most of the topics have a very low level of activity. In fact, the median number of interactions per topic across the sample is four interactions, meaning 50% of the topics pursued have four interactions or less through the 8-week logging period to advance them. On the high side, one participant, Sandra, extended her ‘Education’ learning ecology through 63. Beyond this maximum, Sandra extended another topical ecology by 36 interactions and Adam extended his ‘Education’ topic’s ecology by 34 interactions.

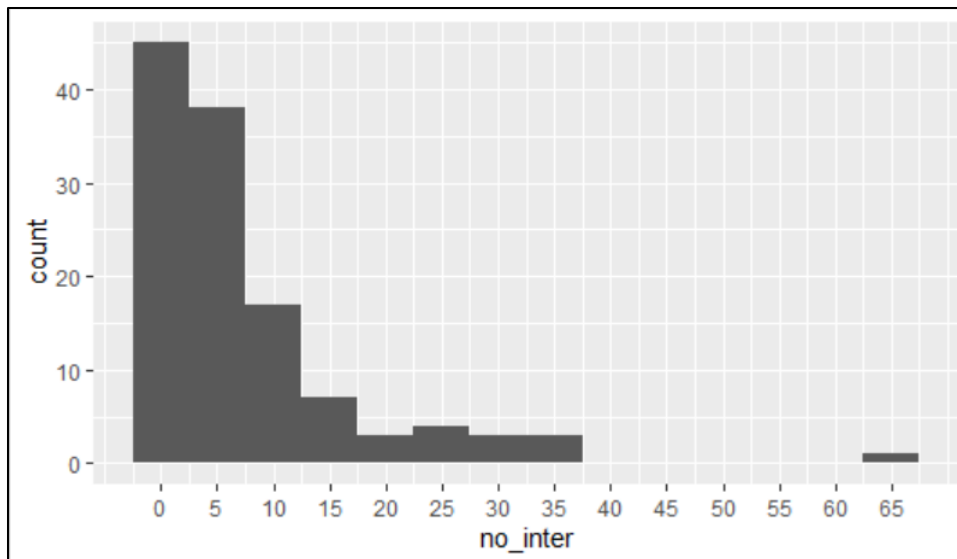


Figure 16 Distribution of topics (count) according to their number of interactions (no_inter)

A lot of the analysis taking place in the coming sections will be applied on two levels; an overall ecological level and a topical ecological level. For these analyses to be meaningful, the level of activity of the topical ecologies analysed should be carefully considered. The study sample entails a total of 121 personal topical ecologies. Of those, 24 ecologies are dedicated by the respective learning to the topic of 'Education', all of which are considerably active with a minimum number of interaction of 6, a median of 16 and a mean of 20. The remaining 97 differ considerably in terms of the level of activity in the ecology, ranging from ecologies in which only one or two interactions took place, to ecologies in which 36 interactions took place. The median for those non-education ecologies is 3 and the mean is 4.3 interactions.

As we analyse the diversity of resources and contexts in the coming sections, a less-active ecology with a mere one or two interactions will bias our understanding. As such a distinction will be made hence forward between active and less-active ecologies. In terms of number of interactions the number 4, one interaction above the median number of interactions – of the non-education ecologies – seems like a fair cut-off score for higher activity. However, learning from Farrah’s case study, in which she had only three interactions pursuing the ‘Voice-over’ topic with a considerable five resources, it seems fair to include another filter of the number of resources, thus including in the active category those ecologies with three or more resources, regardless the number of interactions. Using the first criterion alone 39 topical ecologies are categorised as active ecologies, adding the second criterion adds a mere six more ecologies, including Farrah’s ‘Voice-over’ ecology, which is qualitatively an active ecology. Using both criteria brings the total active ecologies to 45 and total less-active ecologies to 52.

Building on the absoluteness finding concerning topical ecologies, reported upon through qualitative analysis in the first findings chapter, one would expect the 52 less-active personal topical ecologies to be absolute in their composition or characterization (i.e. entailing less diversity of resources and spreading over less contexts). Achieving resource diversity and contextual spread in an ecology through one interaction is extremely difficult. Two or three interactions are less likely to be with two different resources, not mentioning different resource types, and are also less likely to be in two different locations or temporal slots. As such, active non-education topical ecologies are of special interest in the coming sections. They shed

light on how resource diversity, sociability, digitality and contextual spread varies on the topical level versus the overall level, building on the finding from the findings in chapter 5. The Education ecologies bias this comparison as they have all been afforded by the same course.

The 'Education' topical ecology, common to all the participants in our study sample, and afforded by the common experience amongst them, the 'Intro to Education' online course, is still of huge analytical interest as it sheds light on what variation to expect despite the common affordances. Finally, this thesis still raises and answers some questions about the development and outcomes of such less active ecologies.

6.1.2. Overall Ecologies

Learners in the wider sample vary in the number of topics pursued during logging period. Taking a *pursued topic* to be any topic on which at least one interaction has been logged, Figure 17 below shows the distribution of the number of topics pursued along the sample group ($n = 24$). On the high end, one research participant, an outlier in the data, logged interactions on 18 different topics. And on the low end, two research participants logged only one topic, precisely 'Education,' logging mostly interactions related to the 'Introduction to Education' online course. The mean number of topics pursued is 5.125, the median is 5, and the mode is 5.

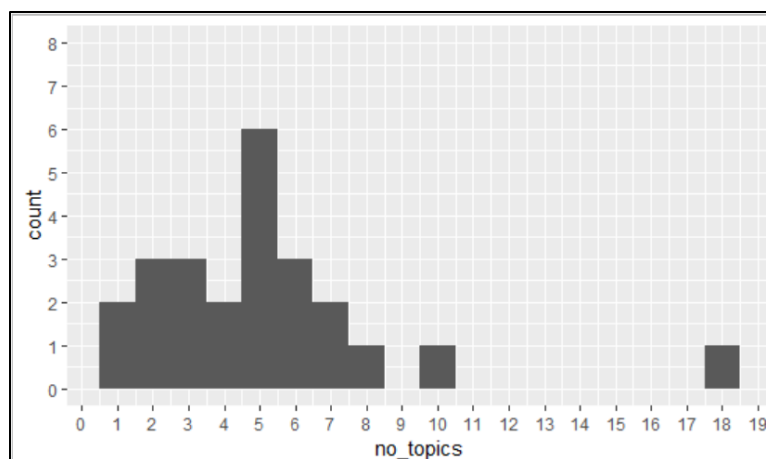


Figure 17 Distribution of the learners (count) according to number of topics pursued (no_topics)

Capturing the number of interactions per topic on the learner level necessitates consideration of the case of Farrah, mentioned in chapter 5. Although Farrah pursued six topics, only three out of those topics were actively pursued. Dividing the total number of interactions by the total number of topics, in Farrah's case, results in 4.2 interactions per topic. Dividing the total number of interactions in the active topics (including 'Education') by the number of active topics, produces 7 interactions. Considering Farrah had 11, 7 and 3 interactions pursuing 'Education', 'Quran' and 'Voice-Over' respectively, the 7 interactions much better represent the number of interactions per topic on a learner level. Adding a sidenote with the number of topics less-actively pursued hence completes the image on the level of activity per topic.

Considering active topics only (including 'Education'), as in Figure 18 below, the maximum number of topics pursued drops from 18 to 9 and the median drops from 5 to 3, and the third quartile of the data is maintained at 3 topics. Unlike the picture painted whilst considering the total number of topics pursued, Adam, Dima, and

Farrah, all with 3 active topics pursued, and Sally with 1 active topic pursued, all, now seem to represent the ‘standard’ of the sample.

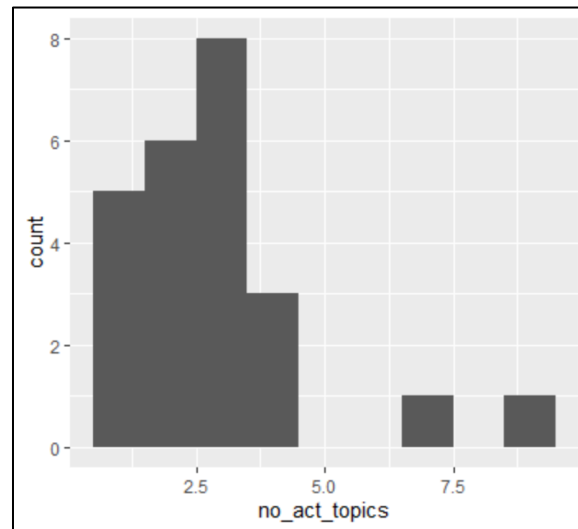


Figure 18 Distribution of the learners (count) according to number of active topics pursued (no_act_topics)

Depth of topical engagement

On a learner level, the average number of interactions per active topic (including ‘Education’) ranges from 5 to 27.5 interactions. The median number of interactions is 11.25 and the mean is 13. The number of topics less-actively pursued ranges from 0 to 9 and the median and mean range between 2 and 3 topics. Adam and Dima, with 20 and 14.6 interactions respectively, unfold as focused learners dedicating an above average number of interactions to their topics, and distracted with zero less-active topics. Sally follows them with 9 interactions, slightly below the average, and with one mere less-active topic. Farrah trails the portrayed group, with 7 interactions per active topic, and 3 less-active topics pursued.

Figure 19 below shows the relationship between the depth and breadth of topical engagement. Depth of topical engagement is represented by the number of interactions per active topic. Breadth of topical engagement is measured by the total number of topics. As the number of topics increases the amount of depth a learner can invest into topics decreases. And in fact, Spearman correlation analysis shows a strong negative significant relationship ($r^s = -0.47$, $p < 0.05$). Spearman has been used here to offset the effect of the value of the outlying 18 topics of Nader.

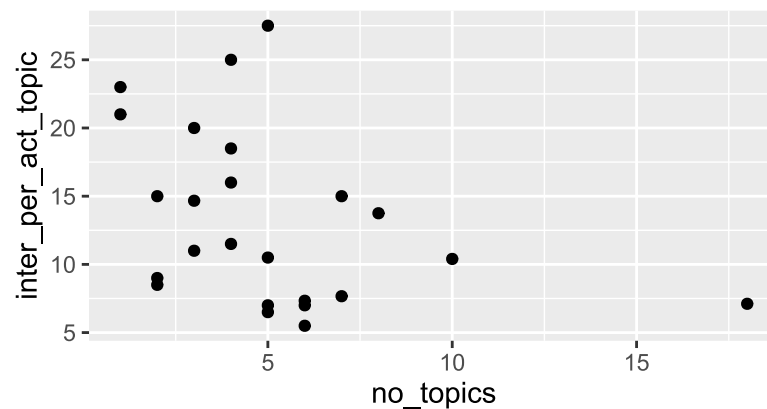


Figure 19 Scatterplot of number of topics (no_topics) by the number of interactions per active topic (inter_per_act_topic)

6.1.3. Topical Dynamism

The weight of each topic (number of interaction on topic / total interactions) in a learners ecology was the result of conscious decisions and unconscious actions dynamically taken on a weekly basis. Dima, portrayed in Chapter 5, reacting to the demands posed by the 'Intro to Education' online course had unconsciously given 'Education' more relative time than she had originally intended or expected. Hannah, on the other hand, had consciously chosen to downplay 'Psychology' in reaction to

the demands of the course. Explaining her level of activity and chosen modes of interaction in her 'Psychology' topic, Hannah said "this is because of the time I allocated.... I had been giving 'Psychology' lesser priority as opposed to 'Education'. Another participant used the word "park" the topic to reflect his topic activity management strategy.

Another strategy identified in this study entailed exploring a topic broadly, in the suppressed pursuit mode, as the foundation for a more intense mode later. Sherry used this strategy with the topic 'programming':

'Programming' during this period was not my priority. I was postponing it a bit. I was just trying to collect some general knowledge about this specific programming language and then after the online course finished, I can start working on it [the programming language].

A third strategy looked more like firefighting. Jay, representing this strategy says:

I cannot organize my time. Rather I work towards the deadlines set by the various entities my studies are associated with. When a deadline in one topic approaches I increase my activity in this topic very much and then my activity decreases again and I move my activity to another topic.

The actual set of topics each of the participants was interested in was greater than those actually logged and pursued during the 8-week period. Sally for one, pursued a number of topics less-actively, however, her pursuit did not meet her standards of learning interactions, as such she did not log them as topics in her learning ecology. Others consciously hibernated them altogether, representing a fourth topic management strategy, during the period of study.

6.2. Resources: Engagement, Diversity and Composition

Learners further their level of mastery along their topics of interest by interacting with resources. Resources, as has been afforded by the framework and enabled by the data collection approach, have been one of most intricately logged aspects of the learning interactions. Study participants indicated whether a resource is social or material, and in each case specified the type of the resource. Working through these intricate descriptions four attributes are of theoretical importance⁵: breadth, depth, diversity and composition. Composition can be noted in terms of sociability (as opposed to materiality) or in terms of the finer grain resource type or category. The data collected through Learmapp, and the interviews, show that in terms of these four attributes, the study sample varies widely, both on the overall ecological level and on the topical ecological level, however some patterns also persist.

The following subsections present the findings of the research with regards to this variation, highlighting the recurring patterns amongst the study participants. The first subsection reports on the findings with regards to the variation in the finer grain composition, noting the prevalence of each of the resource categories along the sample's overall and topical ecologies. This subsection also reports on some qualitative findings with regards to the perceptions of the participants concerning these various categories as reflected in their categorisation of the various resources. The quantitative analysis has been based on re-coding of some of those categorisations to render comparisons amongst participants possible. The second

⁵ This can be traced through the review of the literature and has been explicated in the summary section 2.5

subsection reports on the findings with regards to variations in the breadth and depth of engagement with resources. The third subsection focuses on the diversity of resources. The fourth subsection focuses on composition in terms of sociability. And the fifth and final subsection follows on the finding reported in the chapter 5 concerning the learners' exhibition of some form of ecological signature as they move between topics. This fifth subsection reports on the correlation analysis conducted on the resource ecological metrics⁶ as exhibited in the learners' respective 'Education' ecologies, and their overall ecologies excluding 'Education'.

The subsections also follow on the finding reported in chapter 5 regarding the relative absoluteness of the topical ecologies, or homogeneity, when compared to the overall ecologies. Most of the metrics used to measure the resource parameters are measured on both the topical ecological level and the overall ecological level then compared, highlighting the extent to which this absoluteness finding holds across the wider sample.

6.2.1. Resource Categories

Overall, 470 resources have been recorded by the 24 research participants. Of those 230 form the respective participants' 24 'education' ecologies, and 240 belong to all their remaining 97 ecologies. These resource quantities count the same resource across different participants as the same resource. As mentioned earlier, each of those 470 resources have been designated by its respective logger into either one of 12 categories (social: manager, teacher, family, peer and other social;

⁶ Noted through the four subsections

material: book, article, other text, audio-visual, software, assignment, or other material). Resource categorisation, by the learners, has been largely subjective and necessitated re-coding for proper comparative analysis. The re-coding took into consideration the majority rules and prevalence statistics. Applying majority rules, if a certain resource genre has been designated by a majority of the participants into a specific category, this category was applied across the minority participants too. And sensitive to prevalence statistics if a certain resource is logged by too few participants and too few times it was re-coded into another existing or new category. The re-coding exercise has brought down the number of categories to 10, shown in Figure 20 and Figure 21 below.

With an overall ecological lens, Figure 20 below shows the number of participants, out of 24, who have interacted at least once with each of the 10 categories of resources. The left chart shows category occurrence in learners' overall learning ecology, and the right chart shows category occurrences in learners' overall ecology excluding the education topic. As mentioned earlier, in section 4.3.3., the 'Intro to Education' course has been curated affording interactions with a wide variety of resources, as such, aiming to understand pervasiveness of resources in ecologies, it was necessary to analyse resources occurrences without the 'Education' ecologies' bias. For example, assignments do not occur beyond the 'education' ecology, and other texts (including articles – widely assigned as course readings) drop significantly from occurrence in all 24 learners' ecologies to occurrence in only 12

ecologies. Also, nine participants have not interacted with teachers beyond the 'Education' course instructor.

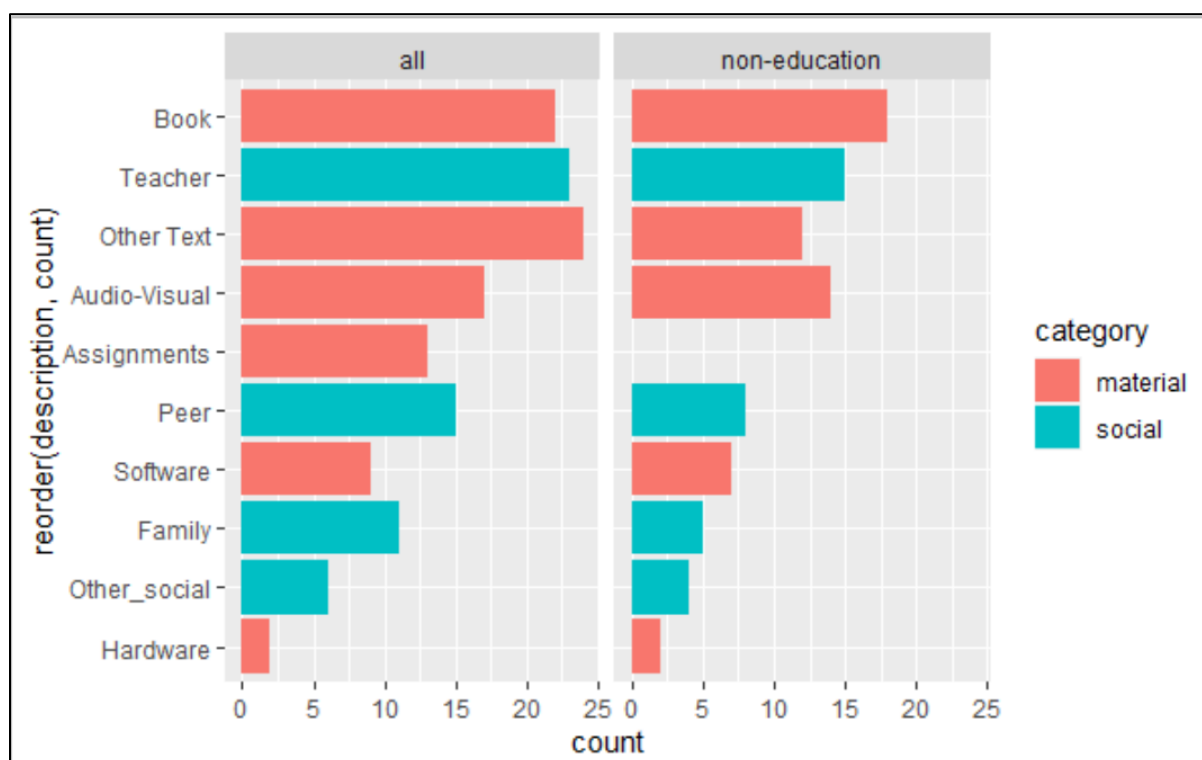


Figure 20 number of participants (count) who have interacted at least once with each of the 10 categories of resources (Overall Ecologies vs Overall Ecologies excluding 'Education')

With a topical ecological lens, Figure 21 below shows the percentage of topical ecologies which include at least one of each of the 10 categories of resources. The first chart on the left shows the number of topical ecologies including at least one of each of the 10 categories, as a percentage of the 121 topical ecologies. The second chart excludes the 24 'Education' ecologies, reporting on the remaining 97 topical ecologies. Teachers lost their second-place ranking to Audio-visuals, and other text, drops to fourth place. The third and fourth charts report on active topics and less-active topics, counting 45 and 52 respectively. Resource occurrences in less-active

ecologies are generally less than that in active ecologies, due to the overall number of resources per topical ecology, as shall be shown in forthcoming subsections.

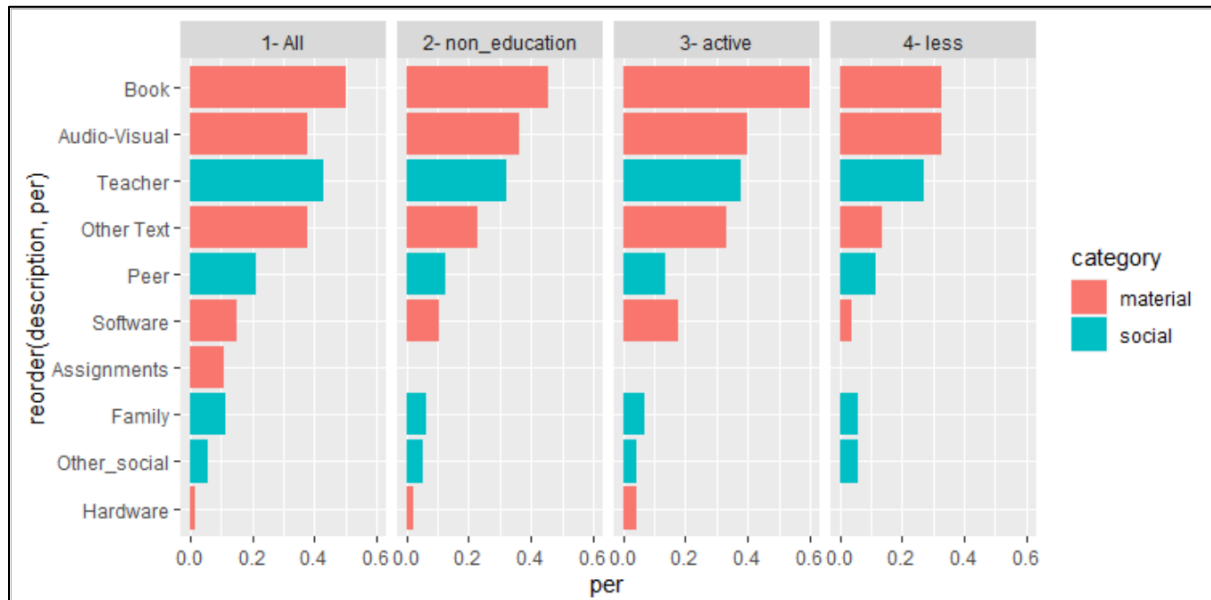


Figure 21 percentage of *topics* (per) which include at least once with each of the 10 categories of resources (All topics vs non-'Education' topics vs Active vs Less-Active)

The following paragraphs are dedicated to the respective categories, presenting key qualitative and quantitative findings.

Books

Books are the resources with the highest prevalence in ecologies. Although they come in third place, after teachers and articles, logged by 22 participants at least once in their overall ecologies. They stand in first position when excluding the 'Education' ecology, which mandated articles as course readings, and entailed a necessary interaction with the course instructor. On a topical ecological level books stand in first position regardless the subset of ecologies. 50% of the 121 topical

ecologies involved at least one book, 45% of the 97 topical ecologies excluding 'Education', and 60% of the active ecologies. With a mere 30% prevalence amongst the less active ecologies, books seem more likely within active ones.

The Quran, the Holy book of all the research participants, was logged by seven of them. In some of the diversity analysis beyond this subsection the statistics will be reported on the books, excluding the Quran, due to its unique nature as a book.

Books, beyond the Quran, still occur at least once in around 50% of the 121 topical ecologies and the 45 active ones.

The research participants were divided when it came to categorising a Master's thesis mandated as one of the required course readings; some categorised it as a book, others as 'other text,' and only one categorised it an article. Following the rules of the majority, this Masters thesis was re-coded as a book, reserving 'other text' as a wider title for shorter form term text-based media.

Shorter Form Text-Based Media: Articles & Other Texts

Articles, as shown in Figure 20 above have been logged by every research participant. From amongst the resources shared, required or optional, by the 'Intro to Education' online course, articles offered the easiest interaction and thus everybody logged interacting with at least one. Excluding the 'Education' topic, however, occurrence of articles drops sharply to almost 15 participants. From a total of 147 articles logged by the participants, only 20 were logged beyond the course readings.

The lines between web articles and websites were unclear. Most of the 20 articles, logged beyond the 'Intro to Education' course, were accessed digitally, through websites of one sort or another. However, Sandra designated an article read in a session, whilst browsing two other websites on the same topic, as a software, then tending to website through which it has been accessed. She logged a reading interaction on another website as an interaction with a software. She also designated a book section accessed through an online browsable library as a software. Another participant categorised a website documenting the usage of a programming language, as other text. Other text amounted to a further 24 resources. Other text included courses notes and official documents, like university catalogues. However, a proportion of the resources categorised as other text were also arguably articles.

Considering the blurry lines, apparent in the participants' perception, between articles, websites, and other texts, and considering their lower numbers, beyond the 'Education' ecology, they have been all re-coded as 'other text'. Other text, as such is the fourth most prevalent resource in ecologies beyond the 'Education' ecology. And similar to books it is much more likely to be involved in an active ecology, 30 out of 45, than a less-active one, 15 out of 52.

Teachers:

The most utilised social resource in this sample group has been teachers. Teachers, as a resource category, sustain second place of occurrence in overall ecologies, regardless the inclusion or exclusion of the 'Education' ecology. Understandably,

each learner, in the sample group, is known to have at least one teacher, namely the instructor researcher (i.e., the researcher), although one seems to have not logged any interactions with this specific resource⁷. Beyond the 'Education' topic, and as shown in Figure 20, the occurrence drops, however remains high at 17 out of the 24 learner ecologies. On a topical level, teachers still have second place with around 40% of the 121 topical ecologies. Teachers are slightly more likely to be part of active ecologies, with 37% of the 45 active topical ecologies involving teachers, than less-active ecologies, with 27% involving at least one teacher.

Some participants, such as Adam and Angie, categorised multimedia as teachers. Adam distinguished between those multimedia recordings of teachers he knows and those he does not, identifying the former as teachers rather than the latter. In both cases, these multimedia resources were re-coded as such, taking asynchrony to be the criterion of exclusion from the teacher category.

Audio-visuals

Although a couple of audio-visuals resources were assigned as required or optional material within the 'Intro to Education' online course, only six participants logged a total of seven resources as such. Two of those resources, logged by the same participant, were recordings of the synchronous sessions of the course, confirming the above-mentioned asynchrony criterion, and as such were left categorised as audio-visual resources. Beyond those some resources were dedicated to the

⁷ This participant arguably included the instructor with her peers, as she used the description 'education course' to denote the resource interacted with in the time of the online sessions. She categorised this resource under the peer category.

'Education' learning ecology, but were not part of the assigned material. These brought the total number of participants logging at least one resource categorised 'Audio-visual' dedicated to the respective 'Education' ecologies to 11.

On an overall, in fourth place in terms of overall ecological occurrence, 17 participants logged at least one audio-visual resources in at least one topical ecology. Active and less-active topical ecologies are equally likely to involve at least one audio-visual resource, with 40% and 33% respectively.

Beyond pre-recorded lectures, accessed as audios or audio-visuals, four participants logged films as learning resources, categorising them as 'audio-visual' resources. Only one of those filmed was a documentary movie, the rest were social drama.

Family, Friends and Peers:

Unlike, teachers, audio-visuals, books, and other text, all prevalent amongst participants, both family and peers seem to be more divisive. Family was logged by 11 participants and peers by 15, although accessible and affordable to all participants considering the affordances of the 'Intro to Education' online course, and Egyptian co-living with family reality, shared amongst all participants.

A total of 14 participants logged interacting with their peers in the online course. Only one participant did not interact with her course peers, and interacted with peers beyond, bringing the total participants who logged at least one peer to the 15 mentioned earlier. Eight participants logged interacting with peers beyond their 'Education ecologies'. On topical ecological level, peers occurred in active and less-

active topical ecologies equally, in six ecologies each, out of a respective 45 and 52 ecologies for the active and less-active topics. Considering 14, out of 24 participants, logged interacting with peers within their 'Education' it is apparent that the 'Education' ecologies course design strongly stimulated more peer interactions than similarly active ecologies.

Peers, sharing an educational or work experiences, have not been distinguished as a category from friends, beyond specific educational or work experiences, in Learmapp. Few participants, however, identified social resources as others, specifying friends in the associated comment field. It was difficult to re-code all the resources categorised as peers into a friends/peers dichotomy, accordingly those categorised as 'others' specifying friends, were re-coded into the peers category. Only two participants logged work-based peers, all other peers recorded were education-based. Both of those work-based peers were recorded across multiple topics. Beyond those, three friends were recorded pursuing multiple topics.

Family, similarly, was utilised across multiple ecologies. three participants logged family members supporting multiple topical ecologies. Also, like peers, family occurred in active and less-active topical ecologies equally, three each. Also, like peers, the online course is associated with more family engagements, total eight, than other active ecologies, three.

Other social (Connections and Strangers):

The loggings categorised into the 'other social' category can broadly be divided into two types: the first of which entails random people a person interacts with in life, considering the interaction a learning one, and the second entails other people who

have some sort of connection however not designated as family, peers, or teachers. Representing the former, one participant logged under the title “unknown person” a passer-by who helped her fix her car, from whom she learned about car maintenance. Dima logged interviewees, which are relatively borderline, between being other connections and strangers, as they are most likely a onetime acquaintance. A point of interest here is that a couple of participants based their ‘Intro to Education’ research projects on interviews, yet only Dima mentioned them as social learning resources.

Examples of the latter include the daughter's teacher, son's school top management, daughter's school bus driver, lab technician, work manager, and life coach. Another point of interest is that although on an overall level 10 participants reported some sort of work engagement, four full-time and six part-time, during the period of the study, only one participant recorded her manager as a learning resource. This same participant recorded her work colleagues, grouped under one resource, as a learning resource, categorised as peers.

Software

One third of the research participants, eight out of 24, logged at least one software, and 14% of the topical ecologies involved a software. Google's search engine was the most prevalent amongst those who logged software, featuring in seven out of the eight participants' ecologies. Four out of those seven participants logged Google

across two different topical ecologies. In many cases the articles and websites browsed through google search engine are part of the learning experience in these google designations. And in other cases they were distinguished as two separate resources. In line with former designation, an article accessed through Mendeley was designated by one participant as a software, considering the medium of access. This designation has been kept unaltered. Separating the search engine from the websites and article it refers to recognises it as a referential resource. On the other hand, although Facebook has been identified in the interviews as referential by many participants, in response to questions asking about how they got to know about a specific response, none of the participants mentioned Facebook as a learning resource.

Language learning has been a prominent topical utilisation for software. One learner, logged Duolingo's (a prominent language learning tool) website and App, as two separate resources, both software. On the other hand, the same participant logged a peer-to-peer language learning website into the "other text" category. This was re-coded into the software category. She also added Google translate, as a software, furthering her learning of the same language. Another participant logged a German language learning website as a software.

Beyond Google, Mendeley and language learning tools, two online databases have been logged, one as a software, by Sandra, and one as 'other material', by Adam. Both have been recorded as software. An examination platform was logged by one participant. And although other participants are known, through the interview, to

have taken online exams, none logged the examination software, or tool, as a separate learning resource. Latex, a software for document editing was logged by one, who was indeed learning how to use it.

Hardware

The 'Other material' category originally included a mere 4 resources. One of those four was Adam's database, re-coded as software, another was Sandra's work deliverable, re-coded, as assignment, and two of which were hardware. Farrah, portrayed earlier in chapter 5, logged a microphone, pursuing her 'Voice-Over' topic. And another participant mentioned laboratory equipment, which are very specific to science learning. However, hardware resources are arguably used in many more learning activities; laptops, computers, tablets, mobile phones, notepads, and pens/pencils. Their pervasiveness might be the reason they are not mentioned. However, although missed in recording, they have been appreciated crucial learning resources in some interviews and reflection statements.

Assignments

Unlike hardware logged by merely two participants, however arguably much more prevalent in learners' ecologies, assignments have been logged by 54% of the participants despite being much less prevalent in the samples' lifelong learners' ecologies, beyond the 'Intro to Education' online course. In fact, assignments have not been logged by any participant beyond the 'Intro to Education' affordances. One volunteer work deliverable, a produced document, logged and categorised by

Sandra under 'other material' has been re-coded into 'assignments', however, still furthering her 'Education' ecology, producing the data shown in Figure 20 and Figure 21 above. The participant mentioned earlier, as the only one to include work manager and colleagues, has not logged any work deliverables as resources, although she reported working on one during the interview.

Self (as a social resource):

From amongst the 24 research participants, three logged 'themselves' as resources utilising the other social category. One of the three participants described the interaction as "An event, reflection and discussion". This specific interaction had two resources: her husband and herself. In re-coding, this interaction has been broken down into two separate interactions, a discussion with her husband and a reflection with herself. Another also had herself logged as a resource, however, in multiple discussions and workshops with colleagues, as if enumerating those present in the events. Considering their nature, the "myself" resource was removed from the interactions. Dima, portrayed in the chapter 5, had a clear-cut reflection with herself. She commented in Learmapp, "I rephrased what my problem with sympathy was like and how it affected my life in the past three years".

In another interaction, pertaining her work on one of the reflective assignments, Dima recorded herself as the only resource in the interaction. This has been re-coded replacing herself with the assignment document aligning with how the other participants logged their assignments. The self as a resource is generally

troublesome to the conceptual framework, presented in the chapter 3, considering learning resources those external to self, and will be discussed considering these findings in the discussion chapter.

6.2.2. Breadth and Depth of Engagement

Learners' further their mastery of the respective topics through interacting, or in other words engaging with resources along the 10 categories, identified above. The engagement pattern, of interactions with resources, has two main parameters: breadth of engagement, and depth of engagement. A learner could conceptually choose to (1) engage with a broad number of resources, overall or per topical ecology, in a shallow manner, (2) engage with a fewer range of resources much more deeply, (3) blend breadth of engagement with depth, conducting more interaction to make this possible, or (4) achieve neither, resulting in less-active topical, and potentially overall, learning ecologies.

Breadth of Engagement

As implied, breadth of engagement, of a learner with resources, can be defined on an overall ecological level, through the total number of resources interacted with, or on a topical level, through the number of resources per topic. The paragraphs below report on findings across the study sample along those two levels, presenting the relationship, in correlation terms, between them, and highlighting the mediation role

of the number of topics, necessary to achieve the 'per topic' part of the calculation. The paragraphs also shed light on multipliable resources, utilised across multiple topics, furthering breadth on the topical level whilst maintaining the overall ecological level. Finally, the paragraphs report on the breadth on a topical level across the 121 topical ecologies, comparing Education, active and less-active ecologies.

The Two Measures of Ecological Breadth

The total quantity of resources interacted with during the whole 8-week period varied greatly from one participant to another. The number of resources per learner for our study sample ranges from 7 to 41, with a mean of 19.7 and median of 17.5. Sally with only 7 resources represents the minimum of the sample. Adam with 19 resources represents the average. Farrah with 21 resources stands slightly above the average. And Dima with 28 resources ranks among the top of the sample, superseded only by Angie, Sandra, and Nader with 41, 39, and 38 resources respectively. Figure 22 below shows the distribution of the number of resources interacted with along the research sample group.

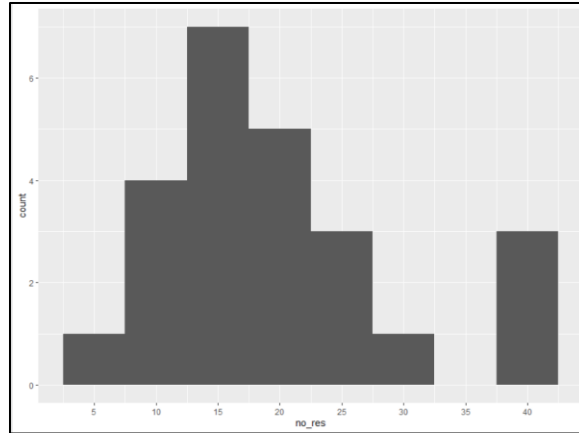


Figure 22 Distribution of the learners (count) according to number of resources interacted with (no_res)

Considering that this total quantity of resources is distributed among several topics that differs from one learner to another, and speaking of breadth, it is necessary to explore how the number of resources *per topic* varies from one learner to another. As such, the number of resources per topic is another worthy measure for the level of breadth of resources sought by a learner. For the sample's 24 learners, on an overall level the number of resources per topical ecology ranges from 1.83 to 12, with a median of 3.8 and mean 5. Sally, thanks to her topical focus strategy, now stands on equal grounds with Farrah, at 3.5 resources per topic, despite the huge variance in the overall number of resources interacted with. Adam, again thanks to his topical focus strategy, despite representing the average number of overall resources, now stands near the borderline of the third quartile of the sample group with 6.33 resources per topic. Continuing her representation of broad engagement of resources, Dima with the fewest number of topics, amongst her counterparts in the top quartile of the overall number of resources, retains her relatively top position, with an average of 9.33 resources per topic. Sandra similarly retains a high position

with an average of 8 resources per topic. On the other hand, Angie falls from the top quartile of overall resources to the group's average of resources per topic, and Nader falls to the bottom of the sample group with the second least number of resource per topic of 2.11.

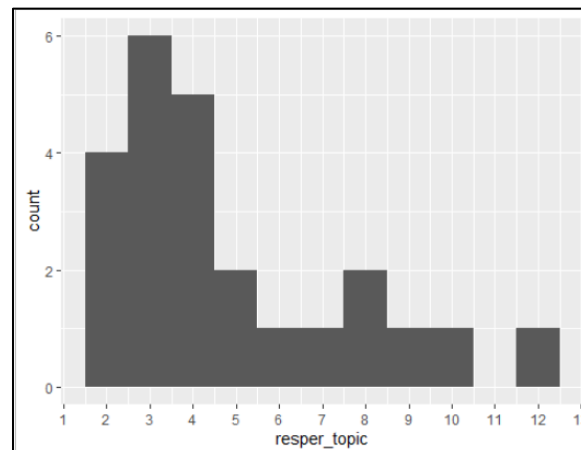


Figure 23 Distribution of the learners (count) according to number of resources per topic (resper_topic)

Relationship between breadth and the number of topics

It is interesting to note that among the top quartile of the sample, in terms of total number of resources, Dima has the lowest number of topics, precisely three. Beyond Dima, and to a lesser extent Sandra, and as one would expect, the total quantity of resources is positively associated with the number of topics pursued. *As if there are limits to the number of resources in singular topical ecology can withhold, however, this will be elaborated upon later.* Figure 24 below plots the total number of resources per learner on the y-axis and the total number of topics on the x-axis. Pearson correlation coefficient for this relationship is a positive 0.67 ($p < 0.001$), and

even off-setting the magnitude of Nader and Angie's significantly higher number of topics through Spearman correlation, the coefficient is maintained at a positive high 0.62 ($p < 0.001$).

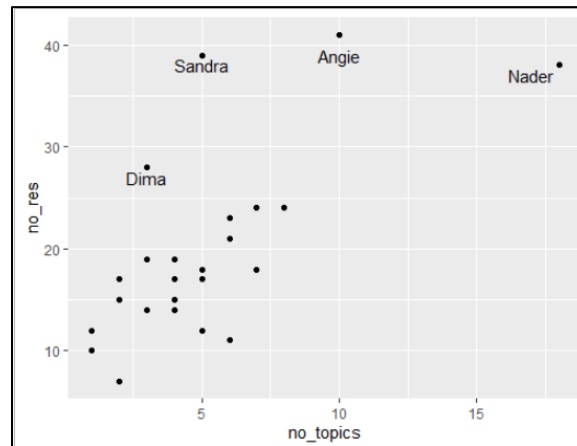


Figure 24 Scatterplot of the number of topics (no_topics) by the number of resources (no_res) for each learner

Unlike the total of resources, a negative relationship has been observed between the total number of topics and the number of resources per topic. Figure 25 below plots the total number of resources per learner on the y-axis and the total number of topics on the x-axis. Pearson correlation coefficient for this relationship is a negative 0.58 ($p < 0.001$), and offsetting the magnitude of Nader and Angie's significantly higher number of topics, Spearman coefficient is increase to negative 0.73 ($p < 0.001$). Accordingly, as a learner commits to more topics, the number of resources she is able to interact with per topic decreases. Taking this relationship with the relationship represented by Figure 24 above, the sample's data implies that adding topics is associated with an increased number of resources, however, at a decreasing rate.

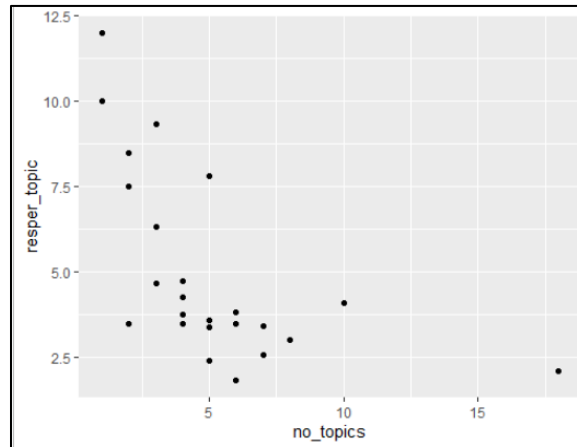


Figure 25 Scatterplot of the number of topics (*no_topics*) by the number of resources per topic (*resper_topic*) for each learner

Relationship between the two measures of Ecological Breadth

The two measures of ecological resource breadth presented above have indeed helped gain insight into the nature of the relation between topics and ecological resource breadth. The question then follows which is a better measure of ecological breadth. On an initial level of analysis, no relationship has been observed between the number of resources per topic and the total number of resources mentioned above. As shown in Figure 26 below, both Nader and Angie, fall below the average number of resources per topic, with Nader almost falling to the minimum number, with 2.17 resources per topic. And both Dima and Sandra are surpassed by two research participants who have focused almost exclusively on the education topic, supported by the online course, during the logging period. Two other research participants, who focused on only two topics actively, come out among the top third of the sample, above the mean of 5.2. Adam is the only other research participant

with an above average number of resources per topic, with 19 resources distributed along 3 topics.

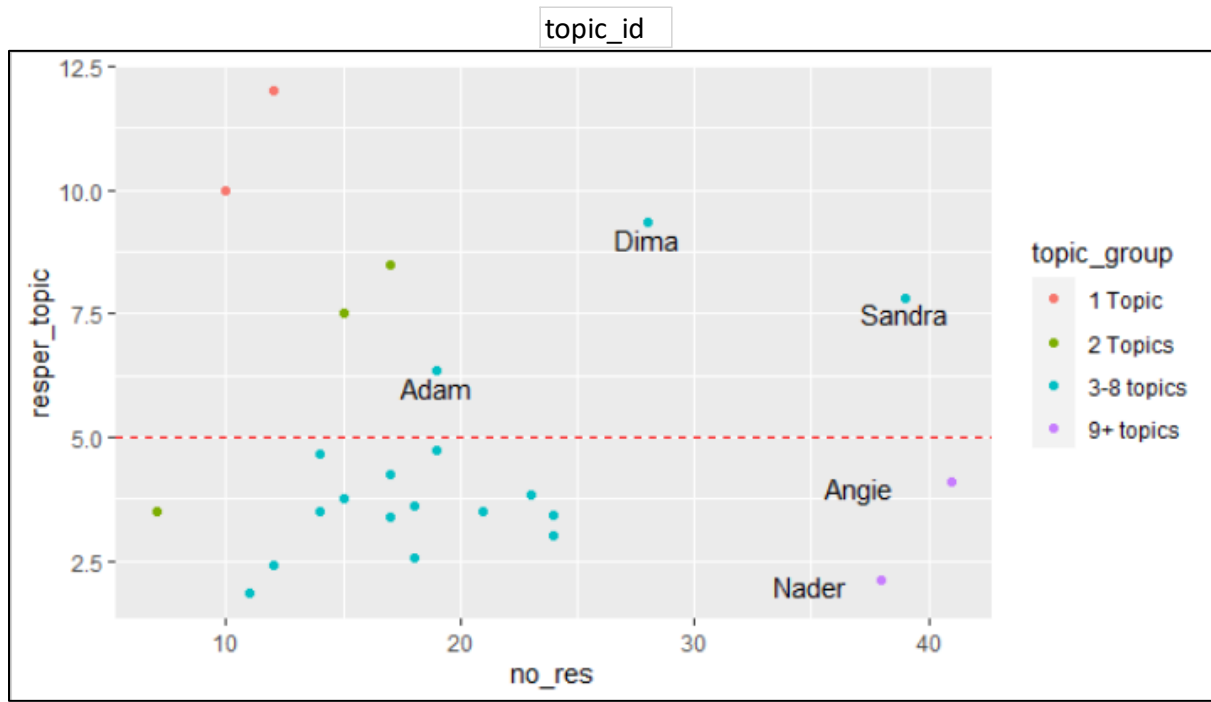


Figure 26 Scatterplot of the total number of resources (no_res) by the number of resources per topic (resper_topic) for each learner, with colour coding for the total number of topics pursued

Considering the relatively strong negative correlation between the number of topics and the number of resources per topic suggests revising the prior relationship studied, namely that between the number of resources per topic and the total number of resources, however dropping the two highest and lowest values for the number of topics. Referring the blue and green dots only in the Figure 26 above a positive relationship can be detected. In fact, the Pearson correlation coefficient between both values, after trimming, becomes a positive 0.35. This suggests that within the standard number of topics pursued zone (from 2 – 8) the more the resources the more the number of resources in respective topical ecologies.

Trimming the two learners with the highest number of topics and the two learners with the lowest number of topics does not change the average number of topics per person, approximately 5 topics, the average number of resources per person, approximately 18 resources, and the average number of resources per topic per learner in the sample group, approximately 4.

Multipliable Resources

It must be noted here that some of the resources interacted with had been logged across multiple topics. The number of resources per topic reported above is obtained by simple division of the overall number of resources by the overall number of topics. Double counting those resources utilised across more than one topic would raise Sandra's number of resources per topic from 7.8 to 9.2 resources per topic. Sandra, the participant with the highest overall number of interactions, utilised 5 resources, out of her 39 resources, across multiple topics, which is the greatest number amongst the 11 participants who have logged the same resources across multiple topics. Those 11 participants logged amongst them a total of 22 resources across multiple topics. The resources per topic numbers were not adjusted to reflect these cross topical resources as their impact is quiet marginal, considering the 22 multipliable resources make-up a mere 4.6% of the total 470 resources. Furthermore, the argument is strong nonetheless for considering learners' breadth without double counting them.

However, attention to cross topical resources is important before moving on to considering breadth on a topical ecological level. Understanding breadth of topical learning ecologies, it is important to note those multipliable resources, which facilitate achieving topical breadth by mere cross utilisation. As has been mentioned in the subsection 6.2.1 detailing the resources categories, the most multipliable of resources on the material front is software, or more precisely google search engine, representing five of the 22 resources utilised across topics, and on the social front it is close connections, broadly speaking, taking up 10 out of the 22 resources, between family, friends, work-peers, work manager and life coach amounted to three, three, two, one and one respectively. A notable mention on the material front is multimedia. One participant appropriated two different lectures of the same video-series (same resource) along two different topics. And, through a work around in Learmapp, one participant managed to log two topics, precisely 'English' and Education' for the same interaction, viewing a movie, precisely "The Story of Ron Clack". A notable mention on the social front is teachers, as two different teachers were utilised cross-topically by two different participants, one of which appropriating different live lectures, along the same lecture series, across two different topics.

Breadth Along the Topical Ecologies

The number of resources per topic per learner, analysed above, calculated simply by dividing the total number of resources by the total number of topics, without duplicating a resource if used across multiple topical ecologies, is unindicative when it comes to understanding the reality of breadth along topical ecologies. Accordingly,

it is necessary to make the topical ecology the unit of analysis to gain further insight into the number of resources per topical ecology. Insights with such a unit of analysis offer a clearer picture about what to expect in a typical topical ecology.

Looking at the whole sample of 121 topical ecologies, the number of resources per topical ecology ranges from 1 to 34, with a median of 2 and a mean of 4.174. This number, as shown in Figure 27 below, is extremely right skewed. The learners' respective 'Education' ecologies, enriched by the curation and motivation afforded by the 'Intro to Education' online course, are exaggerating this average. The number of resources involved in the learners' respective 'education' ecologies range from 4 to 34, with a median of 11 and a mean of 11.5. Excluding the 'Education' ecology, a typical topical ecology ranges from 1 to 10 resources, with a median of 2 and a mean of 2.3. Zooming in on only active ecologies (ecologies with 4 or more interactions during the logging period), we find ecologies still ranging from 1 to 10 resources per ecology, however, with slightly more average resources, with a median of 3 and a mean of 3.4. Resources in less-active ecologies range from 1 to 3, with a median of 1 and a mean of 2. Out of a total of 471 resources, 24 education ecologies contribute 261 resources (55% of the resources), 39 other active ecologies contribute 132 resources (28% of the resources), and the remaining 58 topical ecologies contribute the remaining 78 resources (17% of the resources).

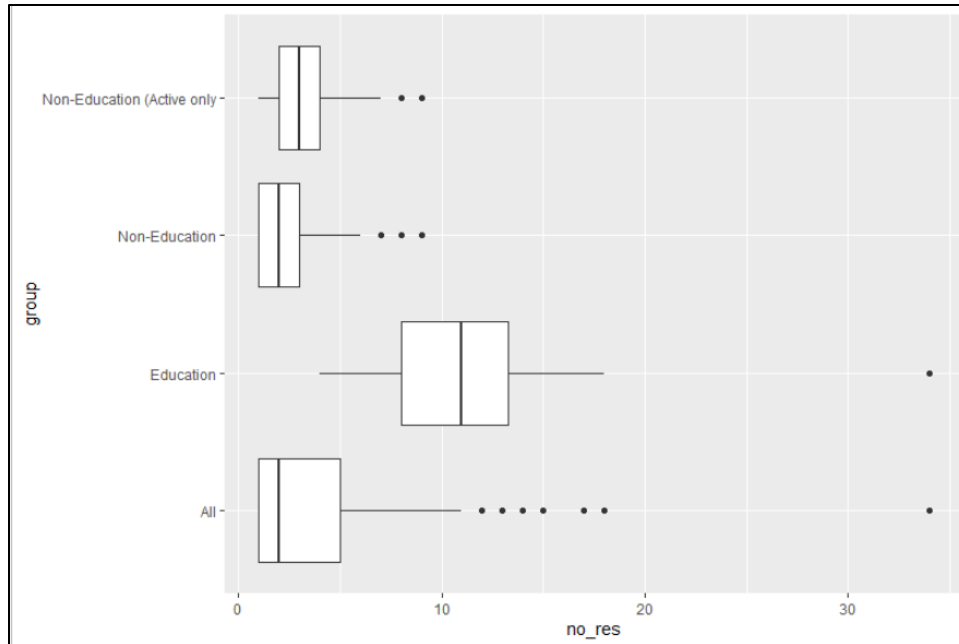


Figure 27 Boxplots of the number of resources (no_res) in topical ecologies (comparing all topical ecologies to 'Education' ecologies to Non-'Education' to active ecologies)

It is quite interesting how the average number of resources in the education ecology is higher than the maximum number of resources in other ecologies, even the active ones. Another interesting finding, however quite expected, is the wide range of total number of resources serving the 'education' ecology compared to other ecologies. This range shows that the 'Education' topic's ecologies show much more absolute variation in the number of resources compared to the non-education ecologies, although working within similar ecological affordances. In fact, the IQR (Inter-Quartile Range) of 5.25 for the 'Education' ecology was higher compared to an IQR of 2 for other ecologies.

Depth of Engagement

The number of interactions per resource is the main metric measuring the depth of engagement. As mentioned in the Chapter 3, and again in section 7.1.4 concerning interactions, the number of interactions is both an outcome of the characterisation of the ecology, and one of the elements of its characterisation. They are an element of characterisation only considered relative to resources or contexts, the two main pillars of ecological characterisation. Observing the number of interactions per resource highlights the depth of the interaction with, or intensity of exposure to, this resource.

Figure 28 below shows the number of interactions per resource across all resources. Looking at the sample's 470 resources, the median number of interactions per resources is 1 and the mean is 2.29. The histogram drops sharply beyond three interactions. In fact, only 15% of resources have been interacted with more than three times and only around 5% of all resources have been interacted with more than five interactions.

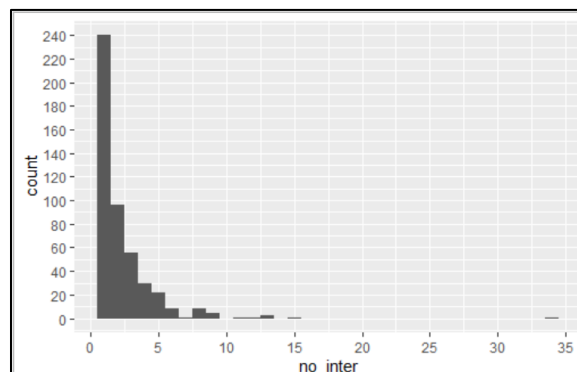


Figure 28 Distribution of resources (count) in terms of the number of interactions (no_inter)

For an individual learner, if the quantity of resources (in overall or per topical ecology) implies the breadth of exposure to resources within the ecology, the number of interactions per resource implies the depth of exposure, or engagement, and the density of the connections in the ecology of resources. Calculating the number of interactions per resource per person, we cannot simply divide the total number of interactions by the total number of resources, as some interactions have multiple resources. In fact, the study participants had on average one fifth of their interactions involving multiple resources (the median percentage of interactions involving multiple resources is 17% and the mean is 22%). Looking at how participants vary in terms of depth of interaction, Figure 29 below shows the distribution of the research participants along the interaction per resource continuum (adjusted for interactions involving multiple resources). The average number of interactions per resource per participant ranges from 1.3 to 3.3, the median is 2.1 and the mean is 2.2, which means that a person, more or less, has two interactions with every resource. Adam having fared medium on the breadth of resources, fares high on the depth with an average of 3.2 interactions per resource. Dima, having fared high on the breadth fares lower than average in depth of interactions, hitting 2 interactions per resource.

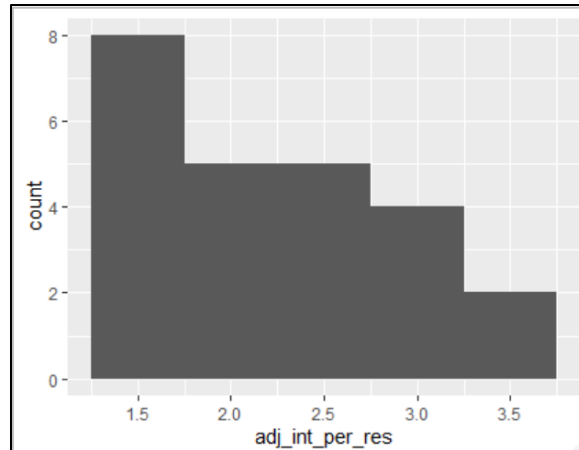


Figure 29 Distribution of the learners (count) in terms of the adjusted number of interactions per resource (adj_int_per_res)

Topical perspective

From a topical ecology perspective, the average number of interactions per resource still centres around two however within a wider range of 1 to 9.5. Interactions with resources within the ‘Education’ topic were well within averages and the ranges thus far explored. On the other hand, interactions with resources within the less-active topical ecologies and active non-education topical ecologies departed the norm greatly. For the former interactions the median is 1 and the mean is 1.47 and for the latter the median is 2.5 and the mean is 3.3. Resources within 12 topics, all of which were non-Education and active, have been interacted with more than four times. No common elements have been observed among those topics.

6.2.3. Diversity and Sociability of Resources

Diversity of resources in an ecology, as mentioned in the literature review, has been taken by many researchers as a sign of ecological health. As detailed in section 6.2.1 above, the resources logged by this research's sample group have been initially designated by the learners, then re-coded by the researcher into one of 10 category, falling under the social or material dichotomy. Diversity measures the extent to which learners diversified their resources along different categories of resources, on an overall and topical levels.

In the paragraphs below report the findings of the quantitative analysis of diversity, measured by number of types interacted with, on an overall and topical levels, in both highlighting the impact of the 'Education' on the overall picture. Considering the absoluteness of topical ecologies with regards to sociability versus materiality, which has been reported in the first findings chapter, the paragraphs below follow the thread reporting on sociability and materiality across the wider sample on overall and topical levels.

Diversity of Categories

From amongst a total possible 10 categories, representing different type of material resources and relationship of social resources, the maximum diversity struck by any participant is 8, the least has been 3. Overall diversity on an ecological level varies in a normal distribution, as per Figure 30 below. With most people interacting with a mixture of 6 different types of resources (median and mean are 6). Sally interacted with 3 different categories of resources, the least amongst the sample group. Adam,

Dima, and Farrah interacted with 8 different types of resources, the highest amongst the sample group. It could be argued however that Dima and Farrah exhibit higher diversity, as both interacted with Films, a subset of audio-visuals resources, unlike Adam.

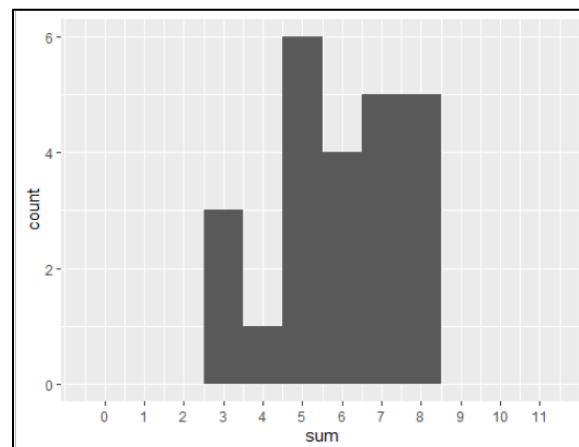


Figure 30 Distribution of the learners(count) in terms of diversity of resource (sum) (measured as the sum of categories of resources entailing at least one resource)

Looking at diversity from a topical ecology perspective, the picture looks much different. Figure 31 below shows the number of types per topical ecology for all the 121 topics logged by the research participants. The number of types ranges from 1 to 7 and the average is much smaller than that of overall ecologies revolving around 2 (the median is 2 and the mean is 2.36). Less active topical ecologies understandably have much less diversity, ranging from 1 to 2 resources, with a median of 1 and mean of 1.3. The interesting finding, however, is that active non-education topical ecologies, similarly, exhibit very little diversity with a median of 2 and mean of 2.178 categories per topical ecology. Only education ecologies exhibit significantly higher diversity with an average revolving around 5 (median is 5 and mean is 4.9). Considering the 'Intro to Education' course, common amongst all

participants supporting their ‘Education’ ecologies, has been designed affording a diversity of resources, it seems topics, even active ones, tend to depend on specific types of resources rather than many types.

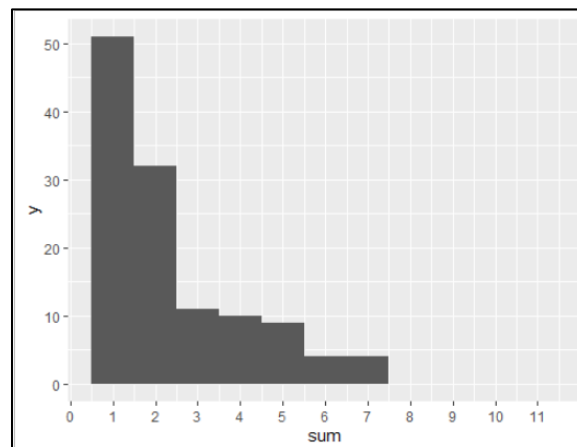
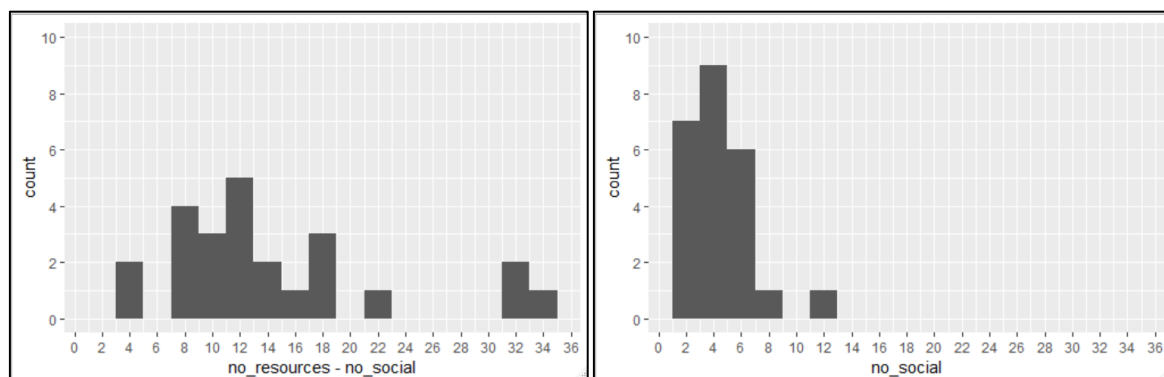


Figure 31 Distribution of topical ecologies (y) according to the sum of categories of resources entailing at least one resource (sum)

Considering this apparent impact of the ‘Education’ ecology on overall ecologies’ diversity, it is useful to go back and consider the diversity, on an overall learner level, excluding ‘Education’ ecologies. Beyond the two participants who did not pursue any topics other than ‘Education’, the average of the sample drops from 6 to 4 (median is 4 and mean is 3.8), with three quarters of the sample group logging a mere 50% of the resources categories.

Sociability

Homogeneity, the opposite of diversity, could be conceived on speaking of resources as either material or social. Figures 32 below shows the distribution of the number of material and social resources along the sample group respectively. On a sample level more material resources are interacted with than social resources, aligning with what was observed on the level of the four participants portrayed in the first findings chapter, and as noticed in the figures below. Considering the overall ecology, the number of social resources interacted with ranged from 1 to 13, with an average of 4.75 and a median of 5. The number of material resources interacted with ranged from 5 to 34, with an average of 15 and a median of 13.



Figures 32 Distribution of the learners (count) according to (left) number of material resources [no_resources - no_social], (right) number of social resources [no_social]

Following on the findings with regards to homogeneity (absoluteness), reported in the first findings chapter, necessitates taking a relative approach, reporting a percentage. The percentage, however, could read social resources relative to total resources, or interactions involving social resources relative to the total number of interactions. In the first measure, sociability and materiality attributes are mutually exclusive and collectively exhaustive, one percentage measure for both suffices. In

the second measure, sociability and materiality are also collectively exhaustive, however, not mutually exclusive as one interaction involving multiple resources can be with both material and social resources concurrently. As such, two separate percentages for materiality and sociability are necessary.

First, Figure 33 presents how social resources as percentage of total resources varies across the sample group. The percentage of social resources ranges from 4% to 58% with a mean of 26% and a median of 26.7%. The predominance of material resources, noted above, is protruded; only two participants have more than 50% social resources, and 75% of the sample group lay below 33% social. Sally and Farrah tie at the centre of this sociability percentage with 28.6% social resources. Sally has lowest number of material resources ($n=5$) and second lowest number of social resources ($n=2$), owing to owing to her overall lower number of resources, or breadth of engagement ($n=7$), which was the lowest among the sample group. On the other hand, Farrah stands around the centre with 5 social resources, and slightly below with 10 material resource. Adam and Dima almost lie on the opposite sides of the scale with regards to sociability. Adam's ecology is a primarily material ecology. He has the lowest number of social resources ($n = 1$), and an above average number of material resources ($n = 18$). In relative terms, material resources constitute 94% of Adam's overall resource ecology. The 'Intro to Education' course's instructor was the only social resource whom Adam interacted with. Dima's ecology, on the other hand, exemplifies a primarily social one. She has the highest absolute number of social resources ($n = 13$) and an average number of material resources ($n = 15$). In relative terms, social resources constitute 46% of her resource ecology,

which, considering the general dominance of material resources in learning ecologies noted above, signals a highly social ecology.

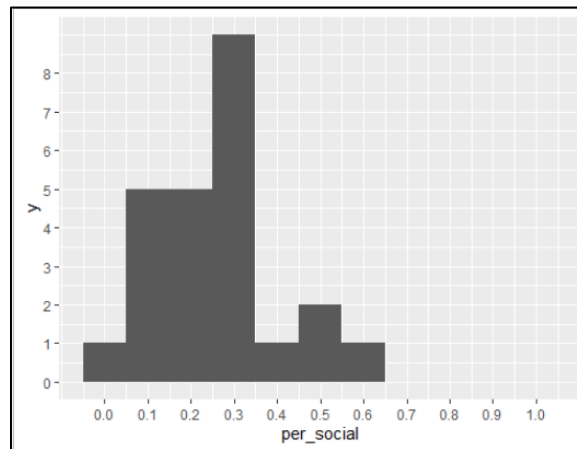


Figure 33 Distribution of the learners (y) according to number of social resources as a percentage of the total number of resources (per_social)

Moving to the second relative measure of sociability and materiality, Figure 34 presents interactions involving social resources as a percentage of total interactions across the sample group. Visually, it seems sociability is faring better. And quantitatively sociability rises drastically in range; from a minimum of 4% to 10%, to a maximum of 58% to 94%, and in terms of average; from a median and mean revolving around 26% to a median of 36% and a mean 41%, with 8 members of the sample group with more than 50% of their interactions involving social resources. This increase in the percentage of social interactions, does not necessarily come at the expense of material interactions. Materiality, still dominating, has the range increasing from a minimum of 42% to 43.75%, the maximum increasing from 96% to a 100%, and the average increasing from around 74% to 75%.

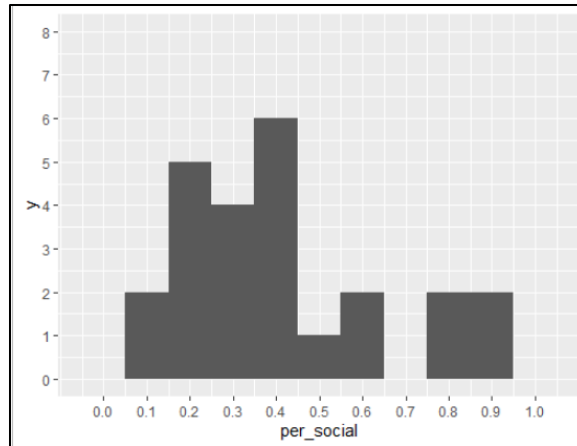


Figure 34 Distribution of the learners (y) according to number of interactions with social resources as a percentage of the total number of interactions (per_social)

Multi-resource interactions explain how both materiality and sociability, taking an interaction perspective, increases as some interactions will involve both material and social resources. Considering sociability increases more than materiality in relative terms, comparing the interaction-view and the resource-view, multi-resource interaction seems to favour social resources. In absolute terms 102 out of 159 interactions involve at least one social resource, however, 121 out of 159 interactions involve at least one material resource. Considering a total of 113 social resources generated these 102 multiple-resource interaction involvements, and 359 material resources generated those 121 multi-resource interactions involvement, it seems social resources are more likely to be involved in multiple interactions. For Adam's highly material ecology, the singular social resource, namely the course instructor, has a high share of the interactions, increasing his sociability from 4% of resources to 13% of interactions, on the expense of materiality with decreases from 94% to 87%. Adam does not have any multi-resource interactions. Dima, Farrah and Sally, engaged in multi-resource interactions, with 27%, 52% and 10% multi-interactions respectively, demonstrate sociability's higher share in multi-resource

interactions. Dima's sociability rises from 46% of resources to 77% of interactions, and her materiality decreasing from 54% of resources to 50% of interactions. Farrah and Sally's sociability increased from 26% of resources to around 62% of interactions, and their materiality decreased from 74% of resources to around 53% of interactions. The fact that sociability and materiality in the three cases add to more than a 100%, explains how sociability increase has not merely been at the expense of materiality, rather social resources were engaged in multi-resource interactions, and more than material resources.

Although homogeneity of resources, in terms of sociability versus materiality, had not been observed on an overall level, as shown above, it is very protruded on the topical level, all in alignment with the findings of the first findings chapter. Using the first measure of sociability, taking social resources as a percentage of total resources, the number of homogeneous topical ecologies is a 71 out of the 121 (58.7%). Of those, 53 are pure material ecologies, and 18 are pure social ecologies. And almost all participants had pure ecologies: 20 out of the 24 participants had at least 1 pure social or material ecology. None of the 'Education' ecologies are absolute, as by design interactions with social resources (at least the instructor) and material resources (required course readings) has been mandated. Expectedly 45 of the 52 less-active ecologies (87%), are absolute. 30 are absolute material and 15 are absolute social. Although active non-education ecologies have an average of 3.5 resources, they are still very likely to be either pure social ecologies or pure material

resources. In fact, 24 of the 45 active ecologies (53%) are homogeneous, divided into 21 pure material resources and 3 pure social resources.

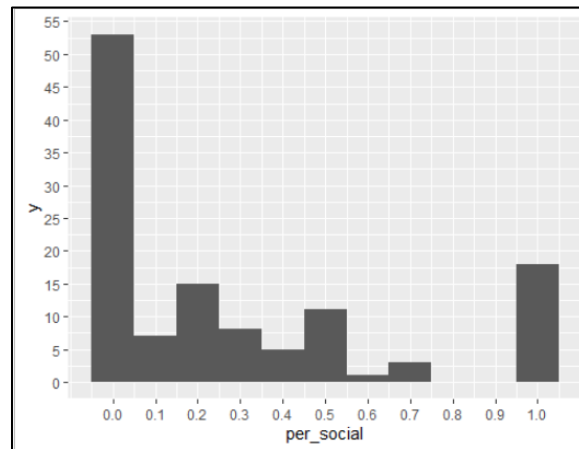


Figure 35 Distribution of the topical ecologies (y) according to number of social resources as a percentage of the total number of resources (per_social)

Taking the second measure of relative sociability versus materiality, homogeneity is extenuated. The number of ecologies in which all interactions involve a social resource rises to 23 ecologies, as 5 five ecologies seem to include material resources interactions with which also entail social resources. And on the other side, the number of topical ecologies in which all interactions involve a material resource rises to 62, with a whopping 9 further ecologies including social resources with whom interactions entailed at least one material resource. The interactions in 3 topical ecologies are both *absolutely* social and material (the 3 are less-active topical ecologies). The number of heterogeneous ecologies moving from a percentage relative to resources, to one relative to interactions, decreases as the basis of comparison decreases from 50 to 39 (32% out of 121). Considering that 21 of these 39 heterogeneous ecologies are the education ecologies, in which heterogeneity was

mandated, the number of heterogenous ecologies falls to 18 (19% of 97). The probability of homogeneity in less-active ecologies is 90% and in active ecologies it is 65%.

Summary of Diversity Findings

Looking at diversity and its antinome, homogeneity, participants in the sample group seem to exhibit the former on an overall level, and the later to the topical one.

Diversity, measured in types decreases from an average of 6 out of 10 categories (or 4 out of 10, if we exclude 'Education' ecologies) on an overall level, to 2 out of 10 on a topical level. And homogeneity, regardless which measure of relative sociability/materiality is taken, is exhibited by the sample's participants in resource choice on a topical level, as opposed to the overall level. On an overall level all ecologies are heterogeneous, involving interactions with both material and social resources. On a topical level, however, 81% of the ecologies, not supported by the 'Intro to Education' online course, have their participants biased towards one side of the social/material resource dichotomy conducting all interactions with either.

6.2.4. Resource Preferences

This sub-section maps onto the final sub-section in the contexts. It follows on the Chapter 5 investigating the potential existence of some form of ecological signature capturing the preferences of individual learning exhibited across topical ecologies. Precisely, Table 13 below reports on the Pearson regression coefficients obtained when correlating the resource parameters as exhibited in the learners' (N = 22)

respective 'Education' ecologies and their overall ecologies, excluding the 'Education' topic's ecology. The number of peers ($r = 0.59$, $p < 0.01$), multimedia ($r = 0.64$, $p < 0.01$), and software ($r = 0.71$, $p < 0.01$) are all strongly positively correlated between the 'Education' ecology and beyond the 'Education' ecology. Those who engaged with their peers in the 'Education' ecology were more likely to engage with peers beyond; those who accessed multimedia resources in 'Education' were more likely to access more multimedia resources beyond; and those who used software pursuing the topic 'Education' were more likely to use software beyond the 'Education' ecology. These findings along with the those in the chapter 5 and in the contexts subsection, will be discussed in the chapter 8 in section 8.1.4 on the ecological signature.

Table 13 Correlation Table of Resource Metrics Between Education Ecologies and Overall Ecologies Excluding Education

Ecological Metrics	r	p
Number of Resources	-0.04	0.88
Sum of Categories (of Resources)	0.15	0.54
Interaction per Resource	0.44	0.06
Percentage of Interactions with Multiple Resources	0.19	0.44
Number of Social Resources	0.18	0.46
Number of Material Resources	0.06	0.80
Percentage of Social Resources	0.37	0.12
Number of Teachers	-0.13	0.60
Number of Family members	0.14	0.56
Number of Peers	0.59	0.01*
Number of Books	0.05	0.85
Number of other texts	-0.12	0.64
Number of multimedia	0.64	0.00*
Number of Software	0.71	0.00*

* $p < 0.05$

6.3. Contexts: Locations, Time, and Virtuality

Contexts, the when and where of the learning interactions, are the third component of learning ecologies, as stipulated by the framework proposed in this thesis.

Building on this framework, three contextual dimensions have been recorded as contextual bearings for each interaction logged by the application users; location, time, and digitality.

In terms of the where and when the learning happens, again the study sample varies widely, both in overall ecologies and in topical ecologies. However, also in alignment with the findings around the resource element of ecologies, some patterns across the study sample persist. The following subsections present the findings of the research with regards to this variation, highlighting the recurring patterns amongst the study participants, and how this variation affects learning. The subsections are organized around the three contextual elements established by the framework of the thesis: locations, time, and virtuality. The subsections treat each of these contextual elements, or bearings separately.

6.3.1. Locations

As mentioned in the methodology section, Learnmapp required users to indicate the location of every interaction, aggregating a list of all locations as learners log their daily learning interactions. Learners were asked to reflect on the locations of their learning in the reflective essay. The logged locations of the interactions were subject of brief discussion in the follow-up interviews. The findings in this subsection emerges from analysis of the data from these three sources.

The absolute number of locations in which the logged learning interactions had been conducted varies among the research participants. Learning ecologies of lifelong learners, accordingly, seem to either spread along many different locations, crossing many spatial boundaries, or centre around just a few. Most of the research participants log learning interactions in more than one location (e.g., home, car, public transportation, ... etc). Figure 36 below shows the distribution of the number of unique physical locations for learning among the sample group (n = 24). On average, learning in an ecology spreads over 4 unique locations (mean = 4.417 and median = 4). Two participants ascribed all their learning to one location, which is precisely their respective homes. Dima, representing sample's maximum, logged interactions, pursuing her 3 topics, in 10 unique locations.

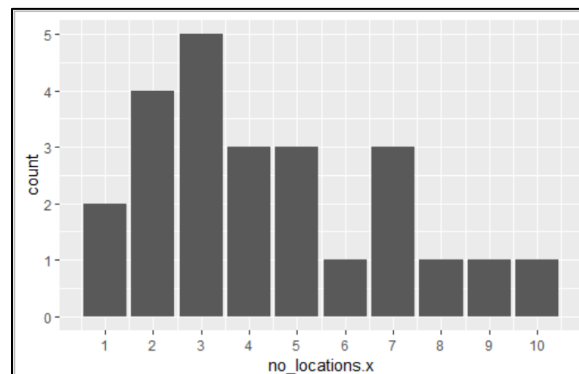


Figure 36 Distribution of the learners (count) according to number of unique locations of learning (no_locations.x)

Abstracting these unique locations into categories of location, the variation between participants persists. Exploring the locations logged across the sample, it becomes apparent that some of these locations belong categorically to the same genre of locations. An example of that would be the 'car' and 'public transportation',

mentioned as examples above, both belonging to a category one can call “in-transit”. In their reflective essays, answering the question about where they conducted their learning, participants tended to aggregate these unique locations into just a few categories. For example, Sandra, who logged learning in 9 different unique locations, bundled learning locations into just three categories: home, a specific social and sports club, and homes of friends and family. Angie bundled 5 unique locations into two categories: home and social/sports clubs. Nader bundled 8 unique locations into 3: home, transportation, and places of worship. Ali bundled 4 unique locations into 3 categories: home, transportation, and public spaces. Building on those categories labelled by the study participants, the unique locations logged by the participants have been coded into eight categories: home, work, university, third spaces, in-transit, informal learning space, family/friends’ homes and other. The other category includes what could not be coded into any of the other categories. Informal learning spaces includes all spaces dedicated to learning, broadly defined, however without the formal designation of being a school or a university, as such learning centres, mosques and therapy clinics have been coded into this category. Third spaces entail other spaces not dedicated for learning, and as such includes social/sporting clubs mentioned above and cafes. Only one participant logged learning in a library, and as such library had been included in the other category.

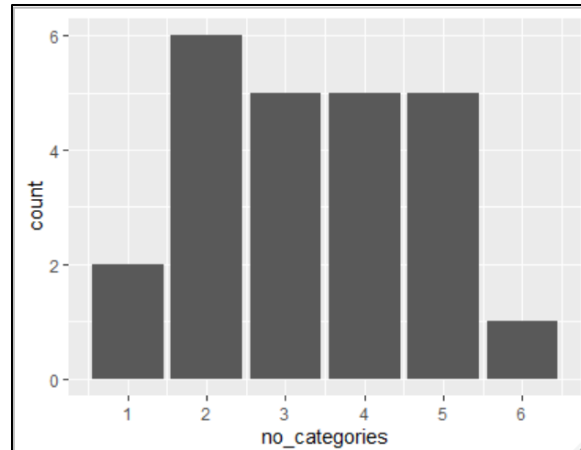


Figure 37 Distribution of the learners (count) according to number of categories of locations (no_categories)

Figure 37 represents the distribution of learners in terms of number of categories of physical locations over which the learning spreads. A learner's overall ecology on average includes 3 of those categories (mean = 3.333 and median = 3), which means that on average two unique locations would belong to the same category per person. Dima has her 10 unique locations belonging to 6 categories. With these 6 categories she retains her position representing the high end of the number of locations in the sample group. Multiple unique locations per category is exhibited mainly in 3 categories: informal learning centres, third spaces and family and friends' homes. Further analysis regarding this multiplicity of unique locations in those 3 categories will be presented later in the respective subsections regarding each of those categories. Figure 38 below shows the number of research participants in the sample group who have logged at least one interaction in each of the 8 categories. Analysis of the categories will be presented roughly in their order of occurrence as per Figure 38 below.

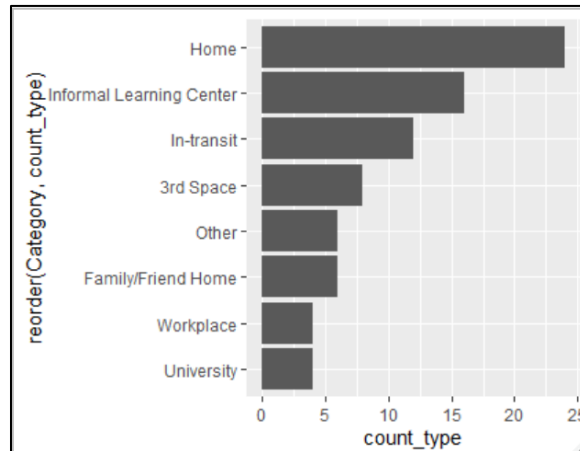


Figure 38 number of participants (count_type) who have interacted at least once with each of the 8 categories of locations

Topical location statistics

Topical ecologies are not as cross boundaries as overall ecologies. A typical topical ecology spreads over 1 – 2 locations (median = 1 and mean = 1.744). As shown in Figure 39 below, 68 out of 121 topical ecologies (56.2% compared to only 5% in the case of overall ecologies) don not spread beyond one unique location. A further 31 out of the 121 (25.6%) spread to only 2 unique locations, one of which is always home. In only 7 out of 121 (or 5%) are multiple locations recorded under the same category in topical ecologies (compared to 45% in overall ecologies). A typical non-education active learning ecology leans towards the higher end of this 1 – 2 range, with a median of 2 and a mean of 1.923. The education ecology, with the relatively mandated extra location of the informal learning centre (which 70% reported as one of their learning locations), had the same median, however a higher mean of 2.75, indicating the existence of a few outliers.

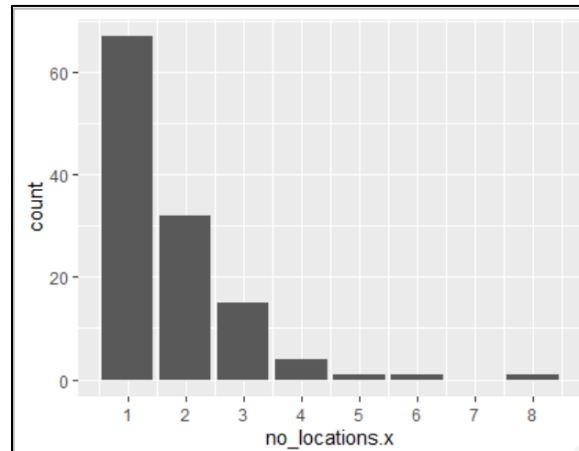


Figure 39 Distribution of the topical ecologies according to number of unique locations of learning
Learning at Home

Home has been the highest logged category across this sample group. All 24 study participants logged at least one interaction at home and on average 73% of each learner's interactions were at home (mean is 73.1% and median is 79%). Figure 40 below is a frequency polygon, with a binwidth of 10%, showing the distribution of the sample participants along the percentage of learning at home continuum. The frequency polygon reveals a bi-modal shape; with a peak around the sample's median of 79% and another peak around 50%. One participant stands between the two groups with 68% interactions at home. Fifteen participants revolve around the higher peak, of whom two participants, as mentioned earlier, have 100% of their logged interactions located at home⁸.

⁸ One of those two participants had physically attended the two sessions of the online course with a face-to-face option, however had not recorded these meetings as such in her logging, and had explicitly mentioned in her reflections that all her learning had been conducted online from her home.

Home has been highlighted as a convenient location for learning, with many participants explicitly identifying the difficulty of moving with their kids to locations of learning. Some participants mention positive statements about the home environment. Many of those participants mentioned internet access and availability of online resources as something that facilitates learning at home. Some participants seemed unhappy by the amount of learning done at home.

Eight participants represent the lower peak, revolving around 50% interactions at home. Ali, heavy on learning in-transit, with 50% home interactions, mentioned more learning at home, “where there’s less distraction,” as positive prospect change in his learning ecology. Layla, 56% home interactions, wished she had done more studying at home, again “where there’s more concentration”.

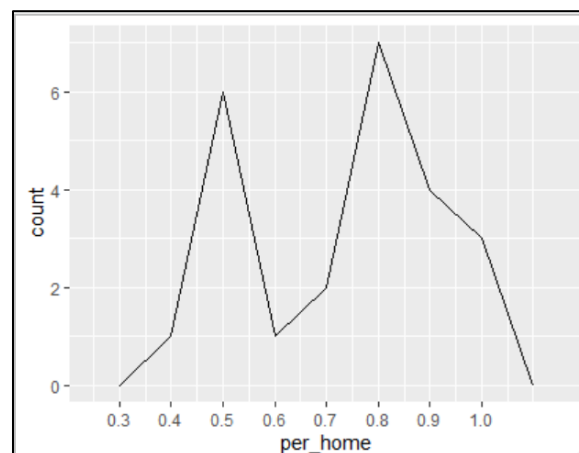


Figure 40 Distribution of the learners according to the percentage of learning at home

Learning at Informal Learning Centres

Informal learning centre has been second in prevalence as a learning space category. Of those who have recorded learning in at least one informal learning centre, this category of space took up an average of 13% of the learner's interactions (refer to Table 14 below). Informal learning centres, as mentioned above, were one of three categories in which some participants logged more than one unique location. In fact, this is the categories with the highest of such occurrences, with 9 participants logging more than one unique location falling under its definition. Two thirds of sample group, or precisely 16 out of the 24 study participants logged at least one interaction in an informal learning centre. Of those 8 who had not recorded any learning in an informal learning centre, 3 have in fact attended physically at least one of the two sessions of the online course with a face-to-face option, however, have not recorded this in their loggings. Of the six participants, recording only one unique informal learning centre, 4 only logged the informal learning centre in which the two face-to-face sessions of the "Introduction to Education" course was conducted. Two participants logged at least one unique informal learning centre each, not being the one designated for our online course, although they did attend at least once at that designated for the course. Finally, informal learning centres, are by their very nature topic related, unlike libraries, which can be used for various topics. Informal learning centres are almost exclusively very topic dependent which explains why they are the category with the highest multiple unique locations per category per person. 7 people recorded multiple unique informal learning centres serving the same or different topics.

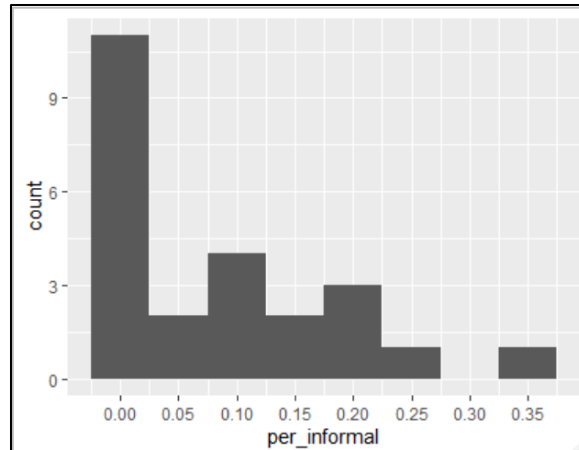


Figure 41 Distribution of the learners according to number of percentage of learning in informal learning centres

Table 14 Average percentage of interactions in the category of space for those participants who have logged at least one interaction in this category of space

Category	Percentage of interactions
Home	73.10%
Informal Centres	13.63%
In-Transit	13.10%
Third Space	4.86%
Family/friends'	14.01%
Work	19.74%
University	14.25%

Learning in-transit

In-transit comes in third, with half of the sample grouping logging at least one interaction in-transit. Of those who have recorded learning in at least once in-transit, this category of space took up an average of 13% of the learner's interactions (refer to Table 14 above). However, this number is not representative of the data, as two individuals, precisely Adam and Ali, are heavily skewing this mean with 50% and 37% of their interaction in-transit, respectively. 10 other participants, nonetheless, do

log at least some learning interactions in-transit, appreciating the opportunity it affords. In the cases of two of those other participants it was travel transportations. And in the cases of at least two thirds of the sample group it was daily commute, to and from work, or dropping off and picking up their kids from school.

Learning in Third Spaces

Third spaces have been fourth in prevalence as a learning space category. One-third of the sample group, or precisely eight out of the 24 study participants, logged at least one interaction in a third space. However, of those who have recorded learning in at least one third space, this category of space took up an average of a mere 5% of the learner's interactions (refer to Table 14 above). This is significantly less than that of the other categories of spaces. Third spaces, as mentioned above, were one of three categories in which some participants logged more than one unique location. Only two participants logged two unique locations. Angie, after highlighting that most of her interactions were from the luxury of her home, even the "all-important" social interactions, through WhatsApp, emphasized that face-to-face learning social interactions are necessary and as such she had organized a couple at different clubs.

Learning at Family and Friends'

Six participants, or a quarter of the sample group, recorded learning at a family and/or friends' home. This category took up an average of 14% of their interactions,

which is similar to the percentage taken up by informal learning centres, in-transit, work, and school. Three of those six recorded more than one family/friend home. Sandra helps us better understand the significance of this category to the sample group, having logged the highest number of unique locations under this category. She recorded 5 different family/friends' homes and she commented in her reflections: "I used to think that the home is the best place for learning, however, after logging I found that studying outside of home might be better in some cases, due to the occupation of kids with friends or family. Especially if this is coordinated with whom I meet (family / friends) by agreeing to meet for studying and having a pre-aligned intention not to waste time on anything else".

Learning at Work and at School

Owing to the nature of the sample group, most of which are stay-at-home moms, workplace and university were some of the least prevalent learning location categories. Four recorded learning interactions at a university and four recorded learning interactions at a workplace. None of the participants recorded learning both at a university and at a workplace. Work and University took up on average 19% and 13% respectively of the interactions logged by participants who have logged at least one interaction in them. Only 5 participants work full-time or part-time, 4 of which logged some learning at work. Only 3 participants were enrolled in full-time or part-time campus-based University program, 2 of which logged learning at the University. The insight here is that lifelong learners committed to work or formal campus-based education tend to indeed conduct some of the learning on work/university premises,

yet this seems, contrary to what one might think, a marginal rather than substantive amount of their overall learning.

Learning at other places

Library has been one of the most interesting other places logged in this study. The only participant who has logged learning in a library lived outside Egypt. In her reflections she emphasized that it is a much suitable environment of learning than home (the only other environment in which she logged learning). Home was preferred, as per her opinion, when learning involved discussions with others and reading aloud.

Few participants logged learning in random places in which she spent some time, expressing resolve in taking up various opportunities of learning. One participant recorded reading a book at a paediatrician's clinic. The interesting point is that she had multiple separate interactions with the same book along her multiple visits. Another participant took a book along to an army drafting day. Both participants explaining the motivation for learning in these peculiar contexts expressed the long wait time, pre-anticipated, as a major factor.

6.3.2. Times

Time in this analysis is a second dimension of the context in which learning interactions take place. It is as such treated analytically similar to locations. With

analyses identifying how much interactions are spread over the day and/or week and when they are concentrated. These questions are answered on overall and topical ecology level.

Hour of day and day of week are the two main contextual dimensions analysed in this section. As mentioned in the methodology section, Learnmapp required users to indicate the start-time, end-time, and date of every interaction. And, as shall be elaborated in section 7.1.4, the start-time and end-time data entailed lots of data entry errors. Learners were asked to reflect on the times of their learning in the reflective essay and a visualization of their time of learning (as the one presented in figure x and y above for Adam and Dima) has been subject of brief discussion in the follow-up interviews. Data from those two qualitative sources has been used to re-code the time data, with special emphasis on least minimizing the error in start-time. The number of hours of day are 24 and days of week are 7, together they bring forth 168 possible slots of time in which learning interactions can take place every week. An interaction is ascribed to a specific hour if it had started during this hour and to a specific day if it had started during this specific day, even it had continued to the next day (such as if the interaction started at 11:45 pm and continued to 01:15 am).

Learners have on average logged interactions in 7 out of the 7 days⁹ (mean = 6.75 and median = 7), however some study participants have logged interactions in only 5 or 6 days. They have on average logged interactions in 13 out of the 24 hours (mean = 12.75 and median = 12.5), and number of hour slots amongst learners ranged on

⁹ Meaning that on average learners spread their learning over the whole week

5 to 22. And they have logged interactions in 28 out of the 168 hour/day slots (mean = 28.375 and median = 24.5), this means that on average a learners' learning spreads over 17% of the possible hours-slots of a week. The spread over weekly hours ranges from 7 hour/day slots (4% of possible weekly hours slots) to 68 hour/day slots (40% of possible weekly hour slots).

Identifying the modal time period (i.e., the specific hour of day or day of week in which the most learning interactions are taking place) will be done by looking at the whole sample of 24 research participants, and the 892 interactions they've logged, blending that with visual analysis of the distribution interactions along time for individual learners as well. First, with regards day of week, as can be seen in Figure 42 below, Saturday, and to a lesser extent Friday, which together constitute the weekend in Egypt, have a higher total/average number of interactions than the rest of the days of the week. It must be taken into consideration however, that the 'Intro to Education' course's session took place on Saturdays, and the deadlines of its assignments and readings were mostly on that day.

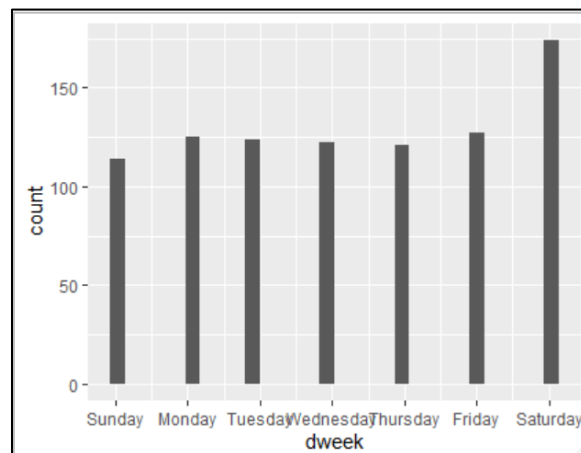


Figure 42 Distribution of the interactions (n = 892) by the day of week

Moving on to the time of day, as can be seen in Figure 43, the collective data seems to be slightly bi-modal with peak hours for learning revolving around noon time and 8pm in the evening, and significantly less learning interactions in the night time and early mornings. Taking time as a continuous variable brings about a mean time, around which the learning interactions in the sample revolve, of 1:45 pm.

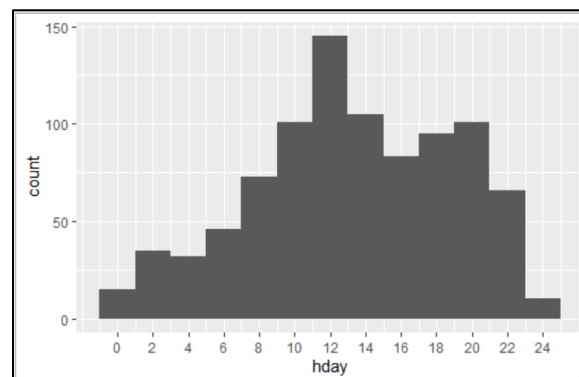


Figure 43 Distribution of the interactions (n = 892) by the hour of day

As revealed by the data thus far, the insights on hours of day and days of week have been extracted on groups of hours (morning, night, evening and afternoon) and groups of day (weekend and weekdays). In fact, like what happened with locations, in their reflections, participants tended to group different days into the weekend/weekday categories, and group hours into night, morning, afternoon and evening categories. In this research each of these four categories has been defined to entail 6 hours, to facilitate analytical comparisons. Morning has been defined to entail from 05:00am to 10:59am, afternoon from 11:00am to 04:59pm, evening from 05:00pm to 10:59pm and night from 11:00pm to 04:59am. These specific hour choices have been made according to the time of sunrise and sunset in Cairo in November and December 2017 (the months in which the data was collected).

Together these 4 groups of hours and 2 groups of days bring forth 8 possible categories of time slots: weekday mornings, weekday afternoons, weekday evenings, weekday nights, weekend morning, weekend afternoons, weekend evenings and weekend nights.

Using these 8 temporal categories one can conceive of the breadth of the temporal footprint of the learner. Figure 44 below shows the distribution of the sample's participants according to the number of time slots (out of 8) in which they logged at least one interaction. The minimum number of categories is 4, the maximum is 8, the median is 7 and the mean is 6.6 categories.

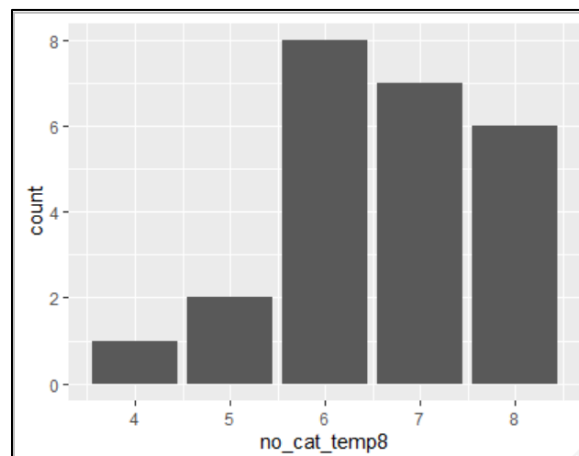


Figure 44 Distribution of the learners according to number of temporal categories (out of a total of 8)

The weekend afternoon, the scheduled time for 'Intro to Education' course sessions, as shown in Figure 45, has been logged by all participants. Weekend nights and mornings have been logged by the least number of participants.

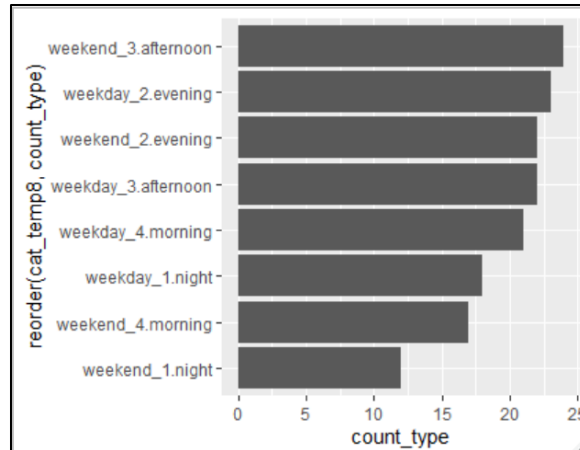


Figure 45 number of participants who have interacted at least once with each of the 8 temporal categories

Topical time statistics

Topical ecologies seem to take up very specific time slots every week, varying within each person bringing out the overall spread observed in overall ecologies. A typical topical ecology spreads over 4.3 of the day's hours, 3.2 of the weeks' days (compared to 12.75 and 6.75, hours and days respectively, for overall ecologies). Out of the fine grained 168 possible weekly hour slots, topical ecologies spread over an average of 6.3 hour-slots, compared to the 28 hours slots mentioned earlier for the overall ecologies. Less-active ecologies, as with the case of locations, understandably skews the topical ecologies' data towards lower contextual spread, given their lower interaction counts. However, excluding the less-active ecologies brings the average to 10.6 hours slots, which is still significantly less than that of the overall ecologies. The education ecology, unlike the case with location, does not mandate spreading the learning over many slots of time, in fact, if it had a skewing effect it would be bringing in more learning towards the weekend as mentioned

earlier. Excluding the 'Education' ecologies and focusing only on active topical ecologies brings forth a spread over 7.4 out of 168 potential weekly hour slots. The 'Education' topical ecologies alone spread over an average of 15 hour-slots, which is still significantly less than that of overall ecologies.

6.3.3. Digital

The final dimension of context explored in this study is virtuality; whether the interaction with the resource was a physical interaction or one on a digital medium, as such is virtual. An interaction logged by the learners on Learnmapp, or using other tools, has been identified as being digital or not. Whilst making sense of the data, and how ecologies tend to vary when it comes to its embrace of digital, it is important to note that all these participants are relatively digital savvy having enrolled into an "online" course.

The percentage of digital interactions ranges from 30% to 100%, the median is 69% and the mean is 67%. Two participants, Adam, and Sherry, as shown in Figure 46 below, exemplify 100% virtual ecologies. Sherry has been recorded, by the researcher, to have attended one session of the 'Intro to Education' course face-to-face, however, she has not logged it in their learning log¹⁰. Dima stands below average with 50% digital interactions and excluding the 'Education' topic from Dima's overall ecology brings the percentage of digital interactions to 18%.

¹⁰ N.B. Sherry did not use Learnmapp to log her interactions

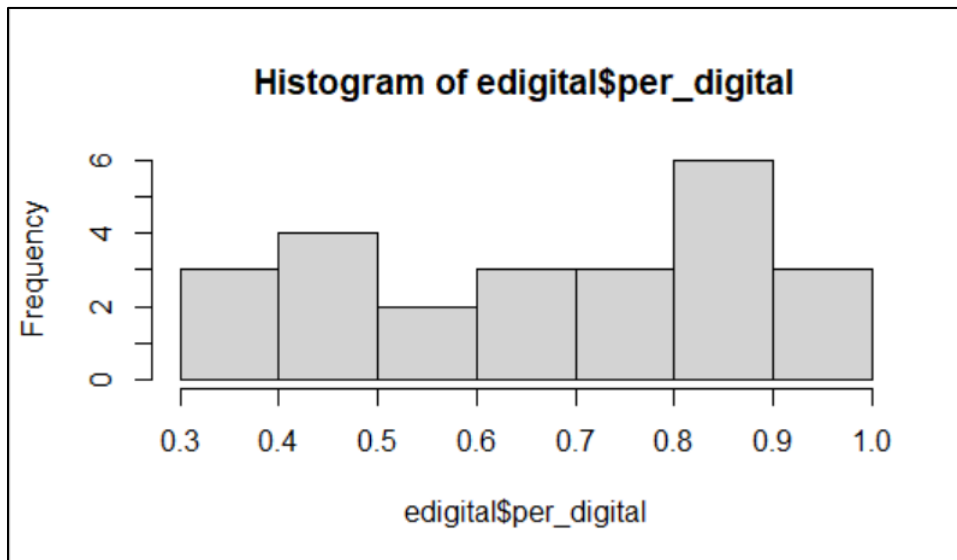


Figure 46 Distribution of the learners according to the percentage of digital interactions

The 'Education' topic, designed as an almost exclusively digital extended experience, with the option of non-digital interactions, has relatively skewed the sample towards the digital side. Figure 47 below shows a boxplot for the 'Education' topical ecologies, against another for other more active topical ecologies (with 4 or more interactions), and a third one for less active topical ecologies. Education learning ecologies, within our sample group, are clearly more digital than other topical ecologies.

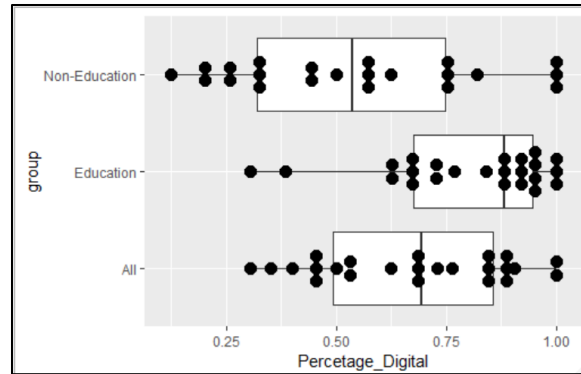


Figure 47 Boxplots of the percentage of digital interactions for topical ecologies (comparing all topics, with 'Education' topics and 'Non-Education' topics)

Unlike overall learning ecologies, which always seem to employ a mix of digital and non-digital learning, topical learning ecologies are much homogeneous; pure digital or pure non-digital. Out of 121 topical learning ecologies 75 (62%) are homogeneous: 40 digital and 35 non-digital. The mean percentage of digital interactions per topical ecology is 57%. These two findings, the number of pure digital topical ecologies and the overall percentage of digital interactions, should not be taken to indicate that, even within this sample group, topical ecologies are more likely to be pure non-digital than digital, considering what has been mentioned earlier concerning the 'Education' topical ecologies skewing the data towards virtuality. In fact, excluding the 'Education' topic brings the pure digital topical ecologies to 37 and the pure non-digital topical ecologies to 35, and the mean percentage of digital interactions per topical ecologies to 51%. Excluding the 'Education' ecologies, on the other hand, exacerbates the homogeneity hypothesis with the percentage of homogeneous topical ecologies rising from the 62%, noted earlier, to 74%.

This hypothesis also stands the test of activity, as less-active ecologies, with 1 to 3 interactions, are expectedly more likely to be homogeneous. Figure 48 below shows the distribution of active non-education learning ecologies according to the percentage of digital interactions. The figure shows 19 out of 39 (48%) active ecologies (on the two absolute sides of the scale: 10 topical ecologies have 100% digital interactions and 9 topical ecologies have 0% topical ecologies. A conclusion can be made about the nature of digital ecologies is that they are more likely to be pure digital or non-digital than a mix of both. Adam, Dima, Farrah and Sally's non-education learning ecologies are cases in point. Adam and Dima lay on opposite sides of the scale, with Adam on the pure digital side with his two active ecologies, and Dima on the pure non-digital side with her two active ones. Farrah's two active non-education ecologies and one of her less-active ones are pure non-digital, and her remaining two less-active ones are digital. Sally's only non-education ecology, less-active, is pure digital.

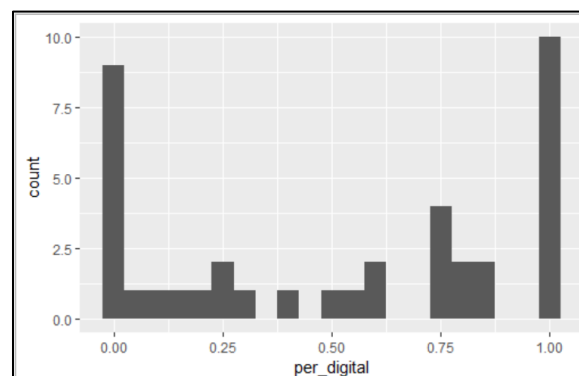


Figure 48 Distribution of the topical ecologies according to the percentage of digital interactions

6.3.4. Contextual Preferences

This section follows on the Chapter 5 investigating the potential existence of some form of ecological signature capturing the preferences of individual learning exhibited across topical ecologies. Precisely, Table 15 below reports on the Pearson regression coefficients obtained when correlating the metric measuring the contextual parameters as exhibited in the learners' (N = 22)¹¹ respective 'Education' ecologies and their overall ecologies, excluding the 'Education' topic's ecology. As shown there are multiple significant positive correlation. First, there is a strong positive correlation between the percentage of digital interactions in the 'Education' ecology and beyond the 'Education' ecology ($r = 0.54$, $p < 0.05$). Learners who took their learning in their learning in and around the 'Intro to Education' online course more digitally tended to take their learning more broadly digitally too. In terms of specific location of interaction, learners who tended to do more learning at home for the 'Education' topic tended to do the same for other topics. Learners who opted to attend the optional face-to-face sessions in the informal learning centre were more likely to have other learning centres in their learning ecologies. The temporal pattern of interaction correlates very strongly between the 'Education' ecology and beyond the 'Education' ecology. Beyond the weekend afternoon slot which hosted the online course's sessions, the patterns map up very strongly.

¹¹ The reason N here equals 22 not 24, is that 2 participants have not logged except the 'Education' ecologies

Table 15 Correlation Table of Resource Metrics Between Education Ecologies and Overall Ecologies Excluding Education

Ecological Metrics	r	p
Number of Time slots (out of 8)	0.08	0.76
Number of Time slots (out of 28)	0.22	0.36
Number of Time slots (out of 48)	0.34	0.16
Number of Time slots (out of 168)	0.29	0.22
Percentage of Digital Interactions	0.54	0.02*
Number of Categories of Locations	0.34	0.15
Number of Unique Locations	0.19	0.45
% of Interaction @Home	0.56	0.01*
% of Interaction In transit	0.45	0.05
% of Interaction @ third spaces	0.08	0.75
% of Interaction @ informal learning centres	0.6	0.01*
% Weekday Morning	0.72	0.00*
% Weekday Afternoon	0.68	0.00*
% Weekday Evening	0.84	0.00*
% Weekday Night	0.9	0.00*
% Weekend Morning	0.67	0.00*
% Weekend Afternoon	0.08	0.73
% Weekend Evening	0.45	0.04*

* p<0.05

6.4. Parameters and Metrics

Considering the importance of the metrics identified through the analyses of this Chapter in elaborating the thesis' framework and in building up to the analyses reported upon the next Chapter, the paragraphs below reiterate the twelve topical parameters along with their measuring metrics.

Topics

1. *Breadth of topics*: This parameter can be measured by the number of topics or the number of active topics in addition to the number of less active topics.
2. *Depth of topical engagement*: This parameter can be measured by the number of interactions per topic, broadly speaking, or the number of interactions per active topic, measuring by dividing the subset of interactions relevant to the active topics only, by the number of those active topics.

Resources

3. *Breadth of engagement with resources*: This parameter can be measured by the total number of resources interacted with, or the number of resources per topic. The former can be measured on an overall level and a topical level. The latter can only be measured on an overall level.
4. *Depth of engagement with resources*: This parameter can be measured by the number of interactions per resource. However, calculating it by dividing the number of interactions by the number of resources results in an underrepresentation of depth as some interactions involve more than one

resource. As such, it has to be adjusted to account for the interactions those interactions.

5. *Diversity of resources*: This parameter can be measured by the number of categories (out of the 10 categories) in which at least one resource has been recorded.
6. *Sociability*: This parameter can be measured by denoting the number of social resources as compared to the number of material resources. Precisely, it could be measured by taking the number of social resources as a percentage of the total number of resources.
7. *Composition*: This parameters is measured by denoting the composition of the ecology in terms of each of the 10 categories of resources. At one level, it could be measured as a binary variable with a 0 denoting that the respective category is not present in the ecology and a 1 denoting it is present. On another level, the number of resources in each category could be noted. On a third level, the percentage of each respective resource category in the ecological makeup could be calculated by dividing the number of resources of this category by the total number of resources.

Contexts

8. *Location spread*: This parameter can be measured by the number of unique locations in which learning has taken place, or the number of categories to which these locations belong.
9. *Location composition*: This parameter by denoting the composition of the ecology in terms of each of the 7 categories of locations. it could be

measured as a binary variable with a 0 denoted that the respective category is not present in the ecology and a 1 denoting it is present. On relative level, the percentage of each respective location category in the ecological makeup could be calculated by dividing the number of interactions in this category by the total number of interactions.

10. *Temporal spread*: This parameter can be measured by the number of time-slots (out of 8) in which learning has taken place.

11. *Temporal composition*: This parameter can be measured by denoting the composition of the ecology in terms of each of the 8 temporal categories. Relatively, the percentage of each respective location category in the ecological makeup could be calculated by dividing the number of interactions in this category by the total number of interactions.

12. *Digitality*: This parameter can be measured by taking the number of digital interactions as a percentage of the total number of interactions.

6.5. Summary

Twelve ecological parameters, describing the three components of ecologies, have been explored over the sections of this chapter. More than 50 quantitative variables have been reported upon measuring these ecological parameters. Beyond the topical parameters, resource and context parameters are measured on the topical and overall ecological levels. Homogeneity in the *diversity and spread* of parameters was observed on the level of topical ecologies much more than overall ecologies, aligning with the findings reported in Chapter 5. Also in alignment with the findings reported in Chapter 5, preferences in the *composition* parameters exhibited in the

learners' respective 'Education' ecologies were showed to carry over onto the respective learners' overall ecologies excluding 'Education'. Table 16 below summarizes these findings.

Table 16 Summary of Chapter 6 Findings

Component	Parameter	Metrics	Ecological Signature	Topical Homogeneity vs Overall Diversity
Topics	Breadth	Number of topics Number of active topics Number of less active topics		
	Depth	Number of (active) Interactions per topic		
Resources	Breadth	Number of resources Number of resources per topic		
	Depth	Number of Interactions per resource		
	Diversity	Number of categories of resources		Yes
	Sociability	Number of social resources Number of material resources Percentage of social resources		Yes
	Composition	Number of (each) resource category Occurrence at least once of (each) resource category Percentage of (each) resource category in ecological makeup	Peers, Multimedia & Software	
Contexts	Digitality	Percentage of digital interactions		Yes
	Locational Spread	Number of unique locations		Yes
		Number of location categories		Yes
	Locational Composition	Occurrence at least once of (each) location category Percentage of interactions in (each) location category	Home and Informal Learning Centres	
	Temporal Spread	Number of times slots (out of 8 categories)		Yes
	Temporal Composition	Percentage of interactions in (each) temporal category	Yes, except Weekend Afternoon	

7. Ecological Outcomes

This section on outcome reports on the findings from the final sets of analyses conducted in this study. Following on the title ‘outcomes’ it aims to present this study’s findings with regards to the relationship between the varieties of ecologies, represented in the variances in the ecological parameters across learners, and the outcome variables. It entails findings from both quantitative and qualitative inquiry. The quantitative inquiry covers first the variance among the sample’s learners along the main outcome variable categories and the relationship among these outcome variables. A second set of quantitative analyses focuses on the relationship between those outcomes variables and the ecological parameters described in the chapter 6. The qualitative inquiry focuses on one of those outcome variables, namely satisfaction, by unearthing the factors affecting satisfaction and dissatisfaction with topical and overall ecologies from the interview transcripts. One section is dedicated to each of those sets of analyses, and the final section entails a summary of the chapters findings.

7.1. Outcomes measures of learning ecologies

From the outset of the research some outcome variables have been identified, some of them applicable on a topical ecological level, some on an overall ecological level and some on both. The first topical outcome variable is the grade in the ‘Intro to education’ online course. Another topical outcome variable is progress along the respective topic, which is applicable to the ‘Education’ topic, along with other topics

individually. Participants were requested to specify their perceived initial level of mastery on a scale of 1 to 10 whenever entering a new topic into the App. They were then request in the interview to provide an update with the current level of mastery on the same scale of the same initial level of mastery. The difference between both level constitutes the self-reported progress. A third outcome variable is satisfaction with the support provided by the ecology. In the interview, the participants were requested to provide a percentage score for each topical ecology individually and then another percentage score for the overall ecology. Thus, this metric is applicable to each topical ecology and the overall ecology. The final outcome variable, applicable only on an overall ecological level, is the level of learning activity, represented by the total number of interactions logged by each of the learners or the logged duration of their learning.

Building up to an analysis of the relationships between the metrics capturing the ecological parameters and these variables, the coming sub-sections will elaborate on those four outcome measures, how the sample group varied along those measures, and the relationship between the outcome measures.

7.1.1. Grades

All 24 research participants pursued the topic 'Education' largely within the affordances of the 'Intro to Education' online course. As such the grade in the course is a considerably good proxy for a learning outcome associated with this specific ecology, shared in pursuit amongst all participants. The grades for the course were

aggregated by the researcher, after grading the individual and group assignments, attendance and participation as indicated in the chapter 4. The median grade in the course was 86%, mean is 82.18%, maximum 96% (scored by 2) and minimum (in the study sample) 49.5%¹³.

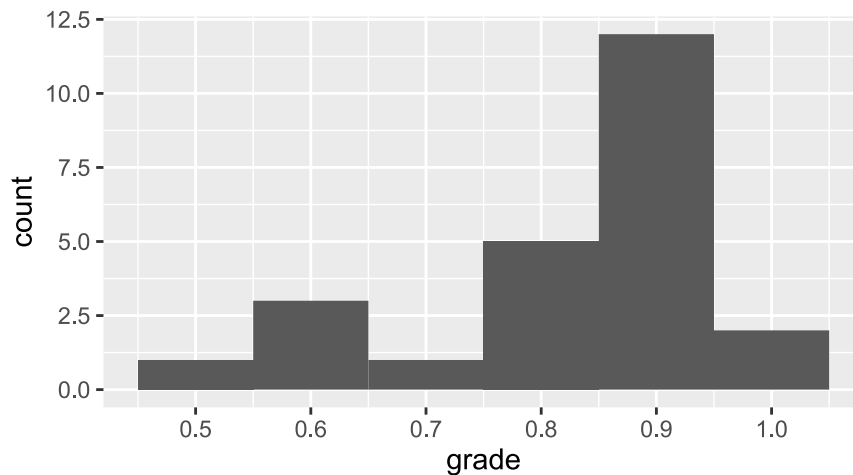


Figure 49 Distribution of learners according to course grade

7.1.2. Progress

Measures of self-reported progress has been calculated for 118 out of the 121 topics logged by research participants. Upon inserting a new topic into the App, participants were requested to indicate their level of mastery on a scale of 1 to 10, here forward named t^0 level of mastery, or initial level of mastery of the topic. In the interviews participants were requested to revise their loggings for this initial level of mastery, or provide fresh ones, for those who have not used the App for logging, or

¹³ Some course participants scored lower grades however were not part of the study sample, either because they did not have enough data, or did not submit any data in the first place.

failed to log this initial level of mastery. Furthermore, in the interviews, participants were requested to indicate their current new levels of mastery, if they had progressed along the topics. Participants were also prompted by the App to report a target level of mastery which was revised during the interviews. Progress can be measured (a) as the absolute difference between the initial level of mastery, t^0 level, and the final level of mastery, t^1 level, (b) as this difference relative to the initial level of mastery, (c) or as the difference relative to the gap between the t^0 and target levels.

On the sample level, progress on the 'Education' topic was higher than that on other topics. Progress in 'Education' ranged from none to 4 scale points, with a median of 1.75 and a mean of 1.65. Considering all the 121 topics, progress ranged from none to 5 scale points, however, with a lower median and mean of 1 scale point. This greater progress on the 'Education' topic was reflected in both the progress as a percentage of the initial level of mastery and the progress as a percentage of the target gap. Learners added a median of 50% to their initial level of mastery of the 'Education' compared to a median of 25% of the initial level of all the 121 topics. And their progress accounted for a median of 26% of the gap between initial level and target level of mastery for the 'Education' topic, compared to a median of 18.75% of all topics.

Only one participant, Angie, reported no progress in the topic 'Education'. Whilst half of the participants reported no progress in at least one of their pursued topics during the 8-week period, bringing the total number of topics with no progress to 31 out of

121 topics. One participant, Nader, reported no progress on 8 of the 18 topics he pursued. Angie reported no progress on three other topics, totalling four out of the 10 topics she pursued. More findings related to the relationship between the number of topics pursued and the various outcome variables will be presented in section 7.2.1 on topics and topical ecologies.

Unlike zero progress, filling or surpassing target levels of mastery was rare. Only Farrah, among the whole sample group, managed to *exceed* a target level, in her topic of 'Voice-over', and expectedly reported an topical ecological satisfaction of 95%. And only Dima, managed to *reach* her target level of mastery in the 'Education' topic.

On a topical level, expectedly, the absolute progress showed a positive correlation that was statistically significant with both the progress as a percentage of the initial level of mastery ($r = 0.81$, $p < 0.05$), and the progress as a percentage of the gap between the initial and target levels ($r = 0.86$, $p < 0.05$).

7.1.3. Ecological Satisfaction

Despite being the only one to reach her target level of mastery in the topic 'Education,' Dima felt the least satisfied by the support provided by her 'Education' topic's ecology. She reported the minimum satisfaction score in the sample group of 20%. The relationship between ecological satisfaction and progress on topic will be explored in the sub-section 7.1.5. The median satisfaction score for the 'Education' topical ecology is 70. The maximum reported satisfaction score is 95%, reported by two participants. Topical ecologies broadly range between the minimum satisfaction

score of 5% and a maximum of 97%. The median satisfaction score is close to that reported for the 'Education' topic, 65%.

The ecological satisfaction measure is a self-reported percentage score obtained during the interviews for each topical ecology separately and then for the overall ecology. The satisfaction score is missing for 8 out of the 121 topical ecologies and for 3 out of the 24 overall ecologies. The median self-reported percentage of overall ecological satisfaction is 70%, the maximum is 100%, and the minimum is 40%.

Sally along with one other participant recorded this lowest score. Adam, again, hits the median, 65%, and Dima falls slightly short, 60%. And Farrah, again, fares high amongst the highly satisfied learners.

There is a correlation between the satisfaction with the topical ecology and the overall ecology. Interestingly, however, an absolute mean of the scores of the individual topical ecologies produces a higher correlation ($r = 0.57$, $p < 0.05$), than the weighted mean ($r = 0.44$, $p < 0.05$) having taken the relative number of interaction dedicated to the topic to designate the weight. This may imply that a higher relative allocation of time does not go along with a higher relative allocation of importance.

7.1.4. Learning Activity

Learning activity is operationalised in this research as interactions. As mentioned in the Chapter 3, the interaction element of an ecology can be viewed as the transaction through which learning takes place and as the outcome of the other elements of the ecology. In this sub-section we work with interactions as the latter,

as one of the outcomes of a learning ecology. The assumption here is that the greater the quantity of afforded interactions the greater the health of the ecology, at least within the intended target ranges of the learner for the period. Sally, with the least overall satisfaction score with her overall ecology (40%) and the least quantity of interactions ($n = 10$), voiced testament to this assumption in her interview, as in chapter 5, however, this will also be taken up further in the coming sub-section concerning the relationship between the various outcome variables.

This study affords two different measures for the amount of learning interactions logged/conducted by the learning; the number of interactions, referred to by many in the literature as ‘frequency’ of the interactions (see for example: Bronfenbrenner, 1979), and duration of learning, arguably falling under Bronfenbrenner’s (1979) ‘intensity’ of the interaction. Although the number of hours of learning might have been a better measure, as it can be related to the intended target ranges of learner for the period, from an empirical perspective and for the purposes of this study the former, the number of interactions, has proved more merit.

First, the number of interactions positively correlates with the duration of learning, whether comparing on an overall ecological level ($n = 24$, $r = 0.83$, $p < 0.05$) or a topical ecological level ($n = 121$, $r = 0.88$, $p < 0.05$). Second, participants’ logging of this variable is much more accurate. Unfortunately, many participants reported they have not been logging the start-time and end-time for the interactions accurately, or have not logged it at all. The start-time and end-time data are especially inaccurate or missing for the participants who opted to using means other than Learnapp to log their learning. The correlation coefficients obtained above collated the learning

duration of the 908 interactions, after significant cleaning and re-coding using the interview transcripts, logged into 24 overall ecologies and 121 topical ecologies thus minimising the impact of these data entry inaccuracies. Working on the level of the 24 participants will result in conducting some analyses with as little as 10 interactions, which will be much more vulnerable to the quality of the data.

As has been observed through the case studies, the number of learning interactions logged by learners within the sample group, during the 8 weeks of data collection, varies widely. The median number of interactions logged in the study sample was 28, and the mean was a 37.50, right skewed towards the maximum of 111 interactions, logged by Sandra, whilst the minimum of the sample was 10 interactions, logged by Sally. An interaction has a median of 90 minutes, and a mean of 104 minutes. The longest interaction lasted around 9 hours, and on the other side of the spectrum interactions were logged as short as 10 minutes.

7.1.5. Relationship between outcome variables

A total of 13 outcome variables have been identified and univariately analysed in the previous sub-sections. Six of those operate on the 'Education' topical ecology level, five on the topical ecological level more broadly and only two on the overall ecological level. This relationship sub-section reports on the findings of correlating the variables associated with each level separately, and then correlating the variables on the 'Education' ecology level with those on the overall level, given the common unit of analysis, i.e. the individual learner.

Education ecology:

Grades in this study, unique as an outcome measure to the 'Education' topic expectedly positively correlates with both ecological satisfaction ($r = 0.48, p < 0.05$) and number of interactions ($r = 0.50, p < 0.05$). Unexpectedly though, there are traces of a negative relationship between progress and ecological satisfaction, on the level of the 24 'Education' ecologies. As mentioned earlier in the ecological satisfaction sub-section, despite Dima being the only one to reach her target level of mastery in the topic 'Education,' she felt least satisfied (20%) by the support provided by her 'Education' ecology. In fact, ecological satisfaction ($n = 22$) showed a weak negative correlation with absolute progress ($r = -0.29, p > 0.05$), strong negative correlation with the percentage progress ($r = -0.55, p < 0.05$) and no correlation with progress as a percentage of the gap ($r = -0.16, p > 0.05$). Considering this relationship with percentage progress, the correlation between ecological satisfaction and t0 level of mastery has been calculated to be a strong positive one ($r = 0.5, p < 0.05$). This correlation suggests that the lower your perceived initial level of mastery the lower satisfaction with the education ecology mostly afforded by the course. It is important to note that the perceived initial level of mastery does not correlate with the grade in the course.

Topical ecologies:

Ecological satisfaction with the topical ecologies showed a mild positive correlation with the absolute progress ($r = 0.29, p < 0.05$) and the progress as a percentage of

the gap ($r = 0.27$, $p < 0.05$). No other correlations on the topical ecological level were observed.

Overall ecologies:

No relationships have been observed between the only two variables applicable to the overall ecological level, precisely the number of interactions and the ecological satisfaction. And concerning the assumption that the greater the quantity of afforded interactions the greater health of the ecology, it seems that the assumption condition, *at least within the intended target ranges of the learner for the period*, is paramount. Sally, with the least overall satisfaction score with her overall ecology (40%) and the least quantity of interactions ($n = 10$), voiced testament to this assumption with the constrain, in her interview, and in fact her actual weekly learning hours on all topics (2.6 hours) were much less than she originally intended (6 – 10 hours). Similarly, Jay, whose satisfaction score is also 40%, managed to average only 6.6 weekly hours of learning although he had intended 8 to 19 hours. Both Sally and Jay were enrolled, and failing to progress, during the 8-week logging period, in postgraduate programs.

The other relationship which seems a little bit more clear from the data on an overall ecological level though, is the impact of the 'Education' topic's ecology. The relationship between the overall number of interactions and the number of interaction in 'Education' showed a positive correlation ($r = 0.78$, $p < 0.001$). And the relationship between the overall ecological satisfaction and the satisfaction with the

'Education' topic's ecology showed a mild positive, however, statistically insignificant correlation ($r = 0.32$, $p > 0.05$).

7.2. How the ecological parameters affect outcomes

Having explored the outcome variables, as expressed in the sample's data, this section moves on to reporting the findings of the quantitative analysis exploring the relationship between these outcome variables and the variables, or metrics, describing the ecological parameters. Grades were excluded from the analysis as they are only relevant to the 'Education' topic. The level of activity was only analysed at the overall ecological level, and the number of interactions has been the metric used in the analysis. Progress was only analysed at the topical ecological level and absolute progress was the measure used in the analysis. Satisfaction has been analysed on both the overall and topical level using the respective satisfaction scores assigned by the participants, rather than the weighted and absolute measures for the overall level. Limiting the number of outcome variables has taken place for better data and results manageability. The strong correlations between the various metrics used to measure each of the outcome has enabled this limitation.

The three sections below entail reports of the quantitative analysis conducted between those chosen outcome variables and the metrics capturing the three main ecological parameters respectively: topics, resources and contexts.

7.2.1. Topics Parameters

Overall Ecology

There are four topical parameters on an overall level: the total number of topics, the number of active topics, the number of less active topics, all measuring breadth of topical engagement, and the number of interactions per active topic, measuring depth of topical engagement. No significant relationship was observed between these variables and *ecological satisfaction*. This lack of significant relationship holds whether this satisfaction is measured by the percentage reported by the respective learner for the overall ecology, or calculated as a weighted or absolute average from the satisfaction scores assigned to topical ecologies. However, significant relationships were observed between the overall level of activity, represented by the total number of interactions, and the topical breadth of the ecology. Precisely, a significant positive relationship has been observed between the total number of topics and the number of interactions ($r = 0.52$, $p < 0.05$), and the number of active topics and number of interactions ($r = 0.71$, $p < 0.05$).

Table 17 Correlation Table of Overall-Level Topical Parameters and Outcome Variables

	Number of interactions	Ecological Satisfaction	Ecological Satisfaction – (Weighted Average)	Ecological Satisfaction – (Absolute Average)
number of topics	0.52*	-0.09	-0.28	-0.28
number of active topics	0.71*	-0.08	-0.26	-0.29
number of less active topics	0.28	-0.07	-0.25	-0.23
interactions per active topic	0.38	-0.13	-0.06	-0.19

* $p < 0.05$

A deeper dive into the relationship between the number of topics and the number of interactions suggests a diminishing returns relationship wherein the number of topics

increases as topics are added, however, at a decreasing rate. Figure 50 below visualizes the relationship represented by the $r = 0.51$ relationship identified in the correlations table, hinting at this decreasing rate of increase. Figure 51 on the other hand shows an inverse relationship ($r = -0.47$, $p < 0.05$) between the number of topics logged, and the average number of interactions per topic (including less-active ecologies). As the number of topics increases the number of interactions dedicated to each topic decreases.

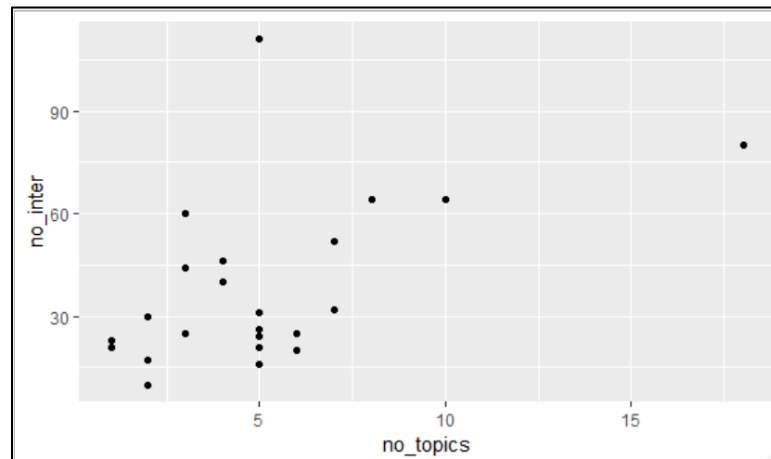


Figure 50 Scatterplot of the number of topics by the number of interactions for each learner

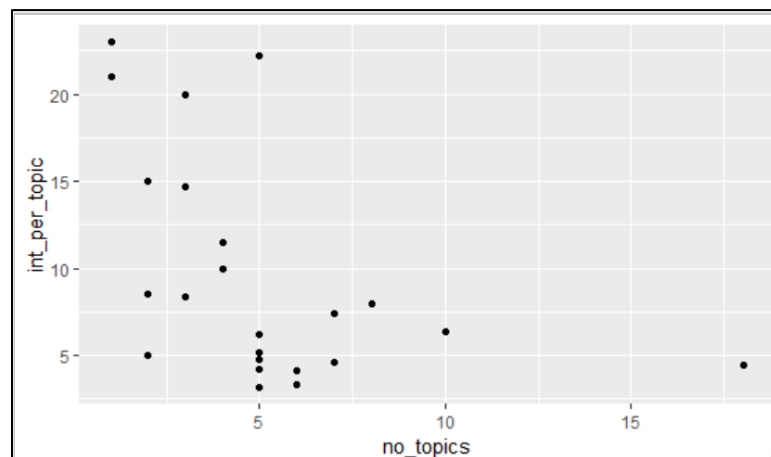


Figure 51 Scatterplot of the number of topics by the number of interactions per topic for each learner

Topical level outcome measures

The section below distinguishes between active topics and less active topics. Table 18 below reports the results of a series of t-tests conducted to compare the ecological satisfaction and progress across those two types of ecologies. As shown there is no significant difference between the ecological satisfaction between these two types of topical ecologies. This holds whether the 'Education' ecologies is included in or excluded from active ecologies. This means that any given learner could be equally satisfied by an active or a more active topical ecology. Progress, on the other hand, is significantly higher in active ecologies compared to less active ones. This however does not hold if we exclude the 'Education' ecologies. On exclusion, less active ecologies have a slightly higher progress mean, however, this is not statistically significant.

Table 18 T-Tests for Differences in Outcome Variables between Active and Less-Active Topical Ecologies

	Less Active		Active (including Education)		<i>T</i>	<i>P</i>
	Mean	SD	Mean	SD		
Ecological Satisfaction	0.600	0.233	0.623	0.233	0.518	0.605
Progress	0.813	1.144	1.280	1.120	2.226	0.028

	Less Active		Active (excluding Education)		<i>T</i>	<i>P</i>
	Mean	SD	Mean	SD		
Ecological Satisfaction	0.600	0.245	0.588	0.233	-0.243	0.809
Progress	0.813	1.182	1.071	1.144	1.071	0.287

7.2.2. Resource Parameters

On the resource level two sets of metrics were related to the outcome variables. The first set entailed metrics capturing the overall picture of resources in terms of breadth, depth, diversity and sociability. The average number of interactions per resource in active topics was used as the measure of depth. The sum of categories to which the resources belong was used as the measure of diversity. Three metrics were used to measure sociability, or social versus material composition: the overall number of social resources, the overall number of material resources, and social (the inverse of material) resources as a percentage of the total number of resources.

The second set of metrics captured the composition of the ecology in terms of the seven prevalent resource categories. Composition, in terms of those seven categories, can be measured as implied in chapter 5 and 6, in multiple ways, begetting different statistical tests. The first set of metrics measure the occurrence of each category, or lack thereof, on overall and topical levels, as binary variables. T-tests have been conducted to analyse the relationship between their occurrence and the outcome variables. The second set of metrics measure the absolute number of resources in each category. And the third set of metrics measure this number as a percentage of the total number of resources. Correlation tests have been conducted to analyse the relationship between those variables and the outcome variables.

Similar to the topical parameters section, these analyses have been conducted on the overall and topical levels. On the overall ecological levels we only have two outcome variables: satisfaction and level of activity. And on the topical ecological level we have two outcome variables: satisfaction and progress. The sections below map on to these levels of analysis.

Overall

Satisfaction:

Considering the resource occurrence realities presented and discussed in Chapter 5, these t-tests were only meaningful to be conducted for the multimedia, peers, family, and software categories. Very few learners had not interacted with at least one book, teacher, or other text. Assignments were non-existent beyond the 'Education' ecology. Hardware was recorded by only two participants and very specific to their respective topical ecologies. The only significant difference ($t = -2.41$, $p < 0.05$) in satisfaction scores was noted between those who interacted with at least one software resource and those who did not. The correlation analysis, on the other hand, shows no significant relationships between the ecological parameters and satisfaction.

Level of Activity:

Breadth of engagement with resources, precisely material ones, and depth of engagement with resources, are both associated with higher level of learning

activity. The correlations analysis reported in appendix E show very strong positive relationships between both breadth of resources ($r = 0.86$, $p < 0.05$) and depth of engagement with them ($r = 0.66$, $p < 0.05$) and the level of activity on an overall ecological level. Increasing the number of interactions per resources (engaging deeper with it) increases the level of activity. However, considering the general limits on the depth of engagement, for a learner to increase their overall level of activity they would have to engage with a broader selection of resources. From the two main divisions of resources, expanding the range of material resources interacted with is the key to expanding overall level of learning activity. The number of interactions showed a strong positive correlation with the number of material resources ($r = 0.86$, $p < 0.01$). And there is a strong negative relationship between the number of interactions and the *percentage* of social resources ($r = -0.45$, $p < 0.05$).

Moving on to the relationship between the composition in terms of the various resource categories and the level of activity, only two categories seem significant and meaningful; **teachers** and **software**.

T-tests exploring the relationship between the occurrence of the resource categories and the number of interactions revealed only two relationships as statistically significant; that with books and that with software. Considering 22 participants logged at least one interaction with a book, this relationship is not meaningful. **Software** occurrence, on the other hand, divided the group. And it has a negative relationship with the number of interactions ($t = -3.22$, $p < 0.01$). The mean number of

interactions for those who have interacted with at least one software resource ($\mu = 22$) is lower than the mean number of interactions for those who did not ($\mu = 39$).

Correlation analysis exploring the relationship between the percentage of each of the resource categories in the overall makeup of the ecology and the number of interactions highlighted only the percentage of **teachers** as significant. Precisely, the correlation analysis revealed a negative relationship between the percentage of teachers in the overall ecology and the number of interactions ($r = -0.63$, $p < 0.05$). The more the learner depends on teachers the less their overall level of activity.

Topical Level

Satisfaction

Looking at the 121 topical ecologies, **diversity** of the categories of resources is the only ecological parameter associated with higher satisfaction. Represented as the sum of categories of resources included at least once in the respective topical ecology, diversity showed positive correlation with satisfaction with the support provided by the respective topic's ecology that was statistically significant ($r = 0.22$, $p < 0.05$). Satisfaction in the less active topical ecologies, on the other hand, does not seem related to diversity of resources interacted with. Beyond diversity, and particularly in the education ecologies, logging **interactions with multiple resources** is associated with higher satisfaction ($r = 0.4$, $p < 0.05$).

Moving on to the relationship between the composition in terms of the various resource categories and satisfaction only three categories seem significant and meaningful; teachers, family and multimedia. T-tests exploring the relationship between the occurrence of the resource categories and satisfaction suggest an increase in satisfaction associated with the occurrence of family ($t = -2.32$, $p < 0.05$), teachers ($t = -2.32$, $p < 0.05$) and multimedia ($t = -2.17$, $p < 0.05$).

Looking at all topical ecologies ($N = 121$), the satisfaction scores in ecologies in which at least one **teacher/instructor** has been engaged with ($\mu = 67\%$) are

significantly higher than those of ecologies in which no teachers have been engaged ($\mu = 57\%$).

Similarly, satisfaction scores with topical ecologies in which at least one **family** member has been involved ($\mu = 74\%$) are higher than those in which no family members have been involved ($\mu = 60\%$). Correlation analysis reinforces the positive impact of family involved on satisfaction, however, precisely in the active ecologies ($N = 42$). The greater the percentage of family in the overall makeup of the topical ecology the greater the satisfaction with this ecology ($r = 0.34, p < 0.05$).

The positive relationship between satisfaction and **Multimedia** occurrence is only observed in Active non-education ecologies ($N = 42$). The satisfaction scores in topical ecologies in which at least one multimedia resource has been interacted with ($\mu = 68\%$) are statistically significantly higher than those topical ecologies in which no multimedia resources have been logged ($\mu = 52\%$). Correlation analysis reveals the opposite of this relationship with multimedia for less-active ecologies ($N = 65$). The greater the percentage of multimedia resources in the makeup of the less active topical ecologies the less the satisfaction with the respective ecology ($r = -0.30, p < 0.05$).

Progress:

Breadth and diversity are associated with higher absolute progress on a topical level. The correlation between the number of resource categories represented in the topical ecology and the absolute progress in that particular topic is a positive statistically significant one ($N = 121$, $r = 0.32$, $p < 0.01$). Considering the case of active ecologies only ($N = 42$) the relationship is mildly strengthened ($r = 0.36$, $p < 0.05$). Breadth, represented by the number of resources making up the topical ecology, is also positively correlated to absolute progress ($r = 0.21$, $p < 0.05$). And from the two main divisions of resources, only the number of social resources is associated with higher progress ($r = 0.25$, $p < 0.01$).

Moving on to the relationship between the composition in terms of the various resource categories and absolute four categories seem significant and meaningful; teachers, family, other text and multimedia. T-tests exploring the relationship between the occurrence of the resource categories and absolute progress reveal significant progress increases associated with the occurrence of teachers ($t = -3.06$, $p < 0.05$) and other text ($t = -3.81$, $p < 0.05$) when looking at the whole sample of topics ($N = 121$). The absolute progress in ecologies in which at least one **teacher/instructor** has been engaged with ($\mu = 1.45$) are significantly higher than those of ecologies in which no teachers have been engaged ($\mu = 0.78$).

Similarly, absolute progress in the topical ecologies in which at least one **other text** resource has been read ($\mu = 1.57$) are higher than those in which no family

members have been involved ($\mu = 0.75$). In the less active topical ecologies ($N = 65$), the involved of family has been significantly associated with a decrease in absolute progress and family ($t = 3.4$, $p < 0.05$). Reinforcing the occurrence findings, correlation analysis reveal that greater absolute progress is associated with greater percentage of other text. This is observed considering the topical ecologies generally ($N = 121$, $r = 0.23$, $p < 0.05$) and active ecologies more specially ($N = 42$, $r = 0.32$, $p < 0.05$), which exclude the 'Education' topic heavy of articles.

The absolute progress in the less active topical ecologies in which at least one **family member** has been logged as a resource ($\mu = 0.13$) are significantly lower than those in less active topical ecologies in which no family members have been logged ($\mu = 0.84$). On the contrary to that family involvement is associated with more absolute progress in active topical ecologies as per the correlation analysis. The greater the percentage of family in the makeup of the active topical ecology the greater the absolute progress ($r = 0.33$, $p < 0.05$).

Finally, the correlation analysis on topical ecologies broadly ($N = 121$), reveals a negative relationship between the percentage of **multimedia** resources and absolute progress ($r = -0.21$, $p < 0.05$).

7.2.3. Contextual Parameters

The contextual parameters under consideration in this study in terms of their effect on the outcomes variables are contextual spread and digital composition. Contextual

spread is locational and temporal. The locational spread is measured by the number of unique locations over which an individual's learning spread and the number of categories to which these locations belong. Temporal spread is measured by the number of temporal slots over which learning spreads out of a potential total of 8, 28, 48 and 168 slots as per the section on contexts in the second findings chapter. Digital composition is measured by the percentage of digital interactions from the overall number of interactions.

Metrics capturing contextual composition, in terms of the specific locations and time slots over which the learning spreads, have not been included, for data manageability purposes. Unlike the limited seven resource categories, the contextual categories rise to more than 16.

Table 19 below summarises the correlation coefficients for these contextual ecological parameters and the outcome variables. The following sub-sections highlight the significant relationships along the three outcome variables: satisfaction, interactions and progress, with a final note of the digitality of the ecology.

Table 19 Correlation Table for the Contextual Variables and the Outcome Variables

	Overall Level		Topical Level	
	number of interactions	ecological satisfaction	ecological Satisfaction	progress
Number of locations	0.52*	-0.21	-0.07	0.21*
Number of categories	0.36	-0.11	-0.05	0.18
Number of temp categories (base 8)	0.42*	-0.12	0.07	0.22*

Number of temp categories (base 28)	0.80*	-0.11	0.09	0.17
Number of temp categories (base 48)	0.82*	-0.24	0.09	0.16
Number of temp categories (base 168)	0.97*	-0.19	0.11	0.13
Percentage Digital	-0.03	0.00	0.09	0.04

Satisfaction:

Quantitative analysis reveals no significant relationship between contextual spread and satisfaction on the overall ecological level or the topical level, taking all the 121 topics as the sample group. The qualitative analysis reported upon in the next subsection painted a more nuanced picture. However, on the level of the of the topic 'Education,' a negative relationship has been observed between the satisfaction with the relevant topical ecology and the number of locations over which the learning spreads ($r = -0.41$, $p < 0.05$). This resonates with the findings of the qualitative analysis and will be elaborated upon in chapter 8.

Interactions:

Returning to the overall level, a higher level of activity is associated with higher temporal and locational spread. Temporal and locational spread was positive on overall, *but indexing it as no of locations or categories for every 10 interactions revealed a negative relationship*. The number of interactions showed a positive correlation with the number of locations over which the interactions spread ($r = 0.52$, $p < 0.01$) Temporally, the number of interactions also positively correlates with the number of temporal categories over which learning spreads with increasing strength

as the number of base categories increases ($r = 0.42$ for base 8, 0.80 for base 28, 0.82 for base 48, and 0.97 for base 168, p for all <0.05).

Progress:

Moving on to the topical level, absolute progress was positively correlated with locational and temporal spread. There was a positive correlation between absolute progress and both the number of locations (0.21 , $p < 0.05$) and number of categories of locations over which learning spreads ($r = 0.18$, $p < 0.01$). Temporally, progress was only statistically significantly associated with temporal diversity with base 8 (weekend/day by morning, afternoon, evening and night). As temporal spread increases, out of a potential 8 slots, the absolute progress increases ($r = 0.22$, $p < 0.05$).

A special note on digital:

The percentage of digital interactions does not correlate of any of the outcome variables at any level. And it is not merely a matter of the significance of the results. The correlations coefficients themselves are very close to zero.

7.3. What would increase your satisfaction?

This section reports the findings that has emerged from the qualitative analysis conducted to probe further into the relationship between satisfaction and the ecological parameters. This qualitative analysis marks the final stage of analysis conducted for this thesis. However, it builds heavily on the case studies conducted in the first stage of analysis. Findings from qualitative analysis of the factors affecting the satisfaction of the four learners, who have been portrayed in the case studies, were included towards the end of each of the respective case studies. The main factors emerging in the interviews with each of the participants were briefly highlighted before further elaboration and contextualisation. The qualitative analysis reported upon in this section entailed a scaling of this factor capture, across the 24 participants, from last section of the interview transcripts, in response to the question regarding what would have improved their learning ecologies. 72 emergent codes, or factors, were then grouped into 12 code categories. Further analysis into these code categories an codes revealed three main themes. The sections below present the findings of this qualitative analysis under these three main themes respectively.

7.3.1. Quantity versus Qualit(ies)

The mere existence of a resource, of a specific type, in the ecology is (in many cases necessary, but) not sufficient to bring about satisfaction with the ecology. The quality of the resource, or the interaction with the resource, is as important. The importance of the various resource categories in learning ecologies have thus been explored through two kinds of metrics concerning their occurrence and quantity. Qualitative analysis of the participants' responses on the satisfaction questions

brings to light another dimension to the discussion, which explains to an extent the quantitative findings reported. This dimension can be broadly labelled as 'quality' as opposed to the quantities which have been the focus of the bivariate quantitative analysis. The concern with quality applies to both the social and material resources, and courses which bundle together groups of specific social and material resources, such as the 'Intro to Education' course. The subsection below elaborates the quantity versus qualit(ies) finding along the social, material and courses headings respectively.

Social Resources

Nine participants mentioned finding peers as something which would elevate their satisfaction with their learning ecologies. And this was very topical; lacking peers on the journey through a *specific topic* was mentioned by many as a reason for dissatisfaction. In some of these cases, peers were available to engage with, however the respective learner failed to engage with them or was frustrated by the engagement. Frustrated by the interaction, Adam, as mentioned in his case study, criticised the lack of preparation and proactivity from his course cohort's colleagues. He had not included them as resources on Learnapp and noted in the interview that their preparation and proactivity would have improved his learning ecology drastically. This lack of preparation, by reading the material resources required, was criticised by Ali and Nancy highlighting some of the sources of dissatisfaction. Precisely, Nancy echoed Adam's concern with peers' participation using the word 'keenness' to describe the quality in her course peers which would have elevated her

satisfaction with the 'Education' ecology. Layla complained about a competitive culture among the peers in another course. This competitive culture caused the peers to refrain from supporting each other.

Quality of the *relationship* with peers were also highlighted by some participants. "if I had known one of the participants on a personal level better in the course... this would have improved my ecology" mentioned Dalia. Nancy echoed and highlighted the lack of the time needed to build proper relationships: "no the ecology was not very supportive; I did not know most of the girls... and there's no time to build a relationship with them". Dima highlighted that a relationship is necessitates communication from both sides and explained that although she benefited through listening to the discussions, in a multiple of her ecologies, to improve her ecology "[she] ha[s] to participate in the discussions too... not listen only".

Moving on to supervisors the same forces of quantity and quality were at play. A number of participants expressed their need for instructor, or mentors, to teach them, or guide them, along specific topics. Dana, highlighted the need for these instructors being 'keen' on their students' learning. Sally, as mentioned earlier in chapter 5, highlighted the importance of two qualities; dedication to her learning and proactive in engagement. Ali somewhat summarised both qualities in requesting 'availability' when he needs them.

Material Resources

Inaccessibility of material resources (due to price and unavailability) was mentioned as a source of frustration by Adam and Nader. However, beyond them, abundance seemed more of the problem than scarcity. Most participants explicated that the “resources are out there”. Identifying the ‘suitable’ or ‘appropriate’ from amongst those resources (to the needs of the specific problem) seemed to be more of the problem. Sally attributed the difference in satisfaction between the ecologies supporting her ‘Islamic Studies’ and ‘General Paediatrics’ topics to her knowledge of the whereabouts of suitable resources and references. Ali highlighted ‘tailored’ reading lists as something which would have improved his satisfaction with one of his topical ecologies. Reading lists would serve two purposes: helping navigate the abundance of resources ‘accessible’; and whilst doing so it would arrange resources in order of difficulty or at list taking into consideration suitability to the learner.

A variant of suitability, relative difficulty, seems to be one of the most important qualities impacting satisfaction. “Pointers for areas to focus on” were recommended by Angie to deal with the difficulty of some of the ‘Intro to Education’ course’s required readings. Language difficulty was highlighted by many. Precisely, the simple fact that the readings in the course were in ‘English’, as opposed to the participants’ native ‘Arabic’, was frustrating to many. One put it “if my English was better... [or] I had more time...”. Another mentioned it was not a problem in the beginning but then “when I started getting [time] pressured I became upset,” she said. The link here is that if it was an easier read she would have been able to read it

while in transit, as an example, opening up the contextual possibilities for interactions. And a difficult read necessitates making time at home for focus interactions. Adam, as highlighted earlier in chapter 5, regarded language as a barrier limiting accessibility to multimedia resources.

Courses

Many participants mentioned access to courses as something that boost satisfaction in respective topics. Courses, or bands of courses, bring together a suite of resources serving the designated topic. It brings together instructor(s), peers interested in the same topic, curated multimedia and text resources, or a mix thereof. Furthermore, courses structure the participants' interactions by necessitating or motivating specific locations or time slots. Several participants, including Adam as in section 5.1.1, mentioned courses being inaccessible (financially, temporally or locationally) as sources of frustration.

Following on the theme of quantity *versus* quality a number of participants cited elements related to the 'quality' of the 'Intro to Education' online course as reasons for frustration. Similarly, courses serving other topics were mentioned as sources of frustration. Considering the course's locational dimension Farrah mentioned requiring the informal learning centre, chosen for the 'Intro to Education' face to face sessions, to be more comfortable. Furthermore, she similarly uncomfortable with the long geographical distance to another informal learning centre supporting another of

her topical ecologies. Temporally, the time-boxes available for interactions with some of the materials of the 'Intro to Education' course were reported as limiting by a number of participants. "It was too much considering the deadlines" commented one participant. On the other hand, Jay complained about another course's lack of exams and deadlines to encourage allocating time for reading.

7.3.2. External versus internal

External forces impacting the ecology:

The external environment, dynamically and statically, was identified as one of the main sources of dissatisfaction. In the static state, family and work commitments were quoted by most participants as sources of dissatisfaction in their learning ecologies, dwarfing the time available for learning. Dynamically, major events in the external environment put pressure on the learning ecologies; two participants were newly wed to each other; two participants were moving homes through the 8-week logging period; one participant had recently become pregnant; and another started weaning her child during the 8-week period. All these major events in the external environment disrupted the daily routines of the learners, decreasing the time available for learning.

Internal factors, external to the ecology:

Thirteen participants discussed internal factors affecting their satisfaction with their respective ecologies. Interestingly, however, most participants distinguished these factors from the ecology itself; they discussed them as factors beyond the learning

ecologies. Responding to the question "how could your ecology be improved for you to give it a better score?" one participant replied "Am I part of this ecology or not? Is it everything except me?". He then went on explaining some personal (internal) factors behind the lower satisfaction score. Another participant explained the importance of the internal factors:

"There is also another factor, which is the psychological personal factor... sometimes the ecology is very good, but I do not have the willpower and determination to make use of this ecology... If I had willpower and determination I would have been more satisfied with my ecology... [She then asked]: Are these psychological factors part of the 'ecology'?"

So the satisfaction score according to this participant was affected by the internal factors, however, again, the internal factor is not part of the ecology. This distinction was not easy for all participants. One participant asked to provide a satisfaction score to one of her topical ecologies said: "Honestly I cannot understand really what percentage I should give it... There was an ecology, but I did not utilise it, I did not use it". Other participants ascribed high satisfaction scores to their ecologies, despite poor interactions and progress, quoting internal factors as the reasons for this lower level of activity and progress.

Broadly speaking the internal factors mentioned affecting the satisfaction with the ecologies were willpower, determination, time management, planning, determination. Dana towards the end of the interview said, emphasizing the word 'learning' as opposed to 'learning ecology':

I see that the biggest constrain in learning is myself. If I have more mettle, plan better, specify my goals better... What exactly I should do the coming period such that I go forward with good, quick and useful steps.

The blurred lines between external and internal:

But then again, these 'internal' factors were not purely internal. Are they innate? Or are they triggered by the external factors? One participant gives some examples that illustrate this dynamic relationship between the internal and external factors:

So theoretically speaking, I've arranged myself that I will listen to these videos one after the other over a 3 hour period... I've dedicated that I will sit this time for this... and I was supposed to start them from 12 to 3... Then I start at 1... and in the middle I go check-up on the kids and sit with them for a little while... so there is much disruption in the lecture... And I'm supposed to be settled on them, cause they are with my mother, not with a stranger. Another time I was in the online course and I had left my child with my husband, yet I have to go check-out on her myself... so I did not focus well... many things dropped off... and I listened to it several times. So time management, worrying too much over many things like my little girl.

Yes, static disruptions do pop-up from the external environment. However, is the external environment the source of their satisfaction or are the internal factors the source. As another participant puts it:

Also there are psychological (personal) issues and problems. There are always unnecessary (unwarranted) interventions (disruptions / interruptions) from the environment, whether family or neighbours, or anybody for that matter... If one dismisses these stuff... but we put ourselves so much into people's words... so we're affected by it.

Dana, again summarising, acknowledges both as separate sources of dissatisfaction:

I see that there are problems with the ecology, and that it can support me more than that, however, I also need to be more focused and more organised.

7.3.3. Relativity: Personal and Topical

Relativity from person to person and from topic to topic was a recurrent theme.

Going through the reasons for satisfaction, dissatisfaction or frustration across the research participants, relativity is the most prevalent theme. What one person perceives as a source of dissatisfaction is perceived by another as a source of

satisfaction or she is neutral towards it. And what one person accepts in one ecology, might very well be a major frustrater in another ecology.

Resource preferences

On the other side of the spectrum to those expressing their needs for peers to interact with in their topical ecologies one participant explicitly identified as "not the social type". At least five participants did not have any peers in their ecologies and did not complain about it. And well more than six other participants did not have peers in each of their active ecologies, and they also did not complain about it.

On the material front, despite being at a disadvantage because of the language of the 'Intro to Education' course, two participants were happy about the fact the course material was in English, and they added 'English' accordingly to their pursued topics.

Resource preferences can also be topical. One participant based the pursuit of one of her topics solely on multimedia resources. She reported being satisfied with this particular ecology. Her objectives in this particular topic did not require deeper engagement, and the videos motivated her to conduct the interactions.

Accepting dynamism

Life is dynamic. The external environment throws two types of demands at learners; dynamic and static. Some saw in these demands their reaction, and their agency,

labelling them as internal problems: “not part of the learning ecologies”. Others attribute them to external factors: the problem is thus with their learning ecologies.

Following on the findings reported in section 6.1.3 on topical dynamism, some participants felt comfortable activating, downscaling and hibernating topics, going with the flow, the ebbs and tides of the requirements associated with the various topical ecologies. Yet other participants struggled, and these dynamics were a major source of dissatisfaction. Dima was a case in point representing the latter group.

Sandra, on the other hand, representing the former group said:

The online course had been taking so much time, so during this period I focused on the course, and after the course ends I can focus on something else. So the ecology of the other topic is not bad. I am the one who chose this. So I am not upset [i.e. not dissatisfied with the other topic's or the overall ecology].

Online versus offline:

Some participants loved working with online documents, others preferred them printed out, and others distinguished according to the type of text and the required type of reading. Some participants cherished the fact that courses were online, giving them convenience. Others expressed their need for face-to-face interaction. Differentiating by topic, Maya expressed the online nature of the ‘Intro to Education’ course as a major frustration, and explicated the complete acceptance of online interactions on another topic, had they been available.

7.4. Summary

Four outcome measures have been considered in this section: grades, progress, satisfaction and overall level of activity. When comparing the data rich 'Education' ecology grades, ecological satisfaction and number of interactions are all considerable outcome variables that positively relate to each other. The initial level of mastery hints at possible explanation to the negative relationship between progress and ecological satisfaction: people with lower levels of initial level of mastery progressed more, however, the course was a bit more difficult than their liking

When comparing the case rich topical ecologies, learners reported satisfaction along with progress as the relevant variables and they positively correlate to each other. When comparing the overall ecologies, learners reported satisfaction along with the number of interactions logged into the App as the relevant variables and they are not related to each other.

The number of topics was positively associated with the overall level of activity. Spreading the learning over several locations and temporally over the week is associated with both higher levels of activity and greater progress on topics, as is increasing the breadth of the engagement with resources; expanding the number of resources interacted with. Material resources are associated with higher levels of activity and social resources are associated with more progress. Depth in the engagement with resources is associated with higher level of activity, and diversity in the categories to which these resources belong, is associated with more progress.

Multiple specific resource categories have been shown as associated with progress and the number of interactions.

Very few ecological parameters are related to satisfaction. Not accounting for the quality of resources/interactions and relativity on a personal and topical level seem to explain this quantitative relative inexplicability.

8. Discussion

This research study had two main objectives. The first of which is proposing and evaluating a systematic and scalable framework to capture empirical data about learning ecologies of lifelong learners. And the second is using this framework to understand the development and outcomes of the learning ecologies of lifelong learners. The framework and an associated data collection approach have been proposed between the framework and methodology chapters. The framework as presented in these chapters is considerably a late iteration informed by an extended dialogue between the literature, realities of data collection, preliminary findings, and late-stage findings. The conclusion, along several of its sections, will entail further reflections on the framework. This discussion also addresses this first objective, in that the findings reported in the three previous findings chapter and discussed here are the main evaluation arena for the framework. Putting the framework into action, the three findings chapters reported on the findings from qualitative and quantitative analysis aimed at answering the questions “what can the proposed framework tell us about how the learning ecologies of lifelong learners are shaped?” and “what are the outcomes associated with varieties of the learning ecologies of lifelong learners?”.

The first findings chapter aimed to answer the questions by presenting and comparing case studies of four of the study’s research participants. Drawing from the data collected by the App, and other sources, the case studies were analysed and presented along the dimensions of the proposed conceptual model, showcasing the conceptual model in action. Contrasting the data captured by the App to that captured by other sources, especially on the ‘Education’ ecology, revealed some

discrepancies. A handful of ecological configuration metrics were compared, according to different data sources, and negligible discrepancies were observed, building relative empirical confidence in the ecological sampling approach. Assessing these ecological metrics across the topical ecologies, in each of the case studies, hinted at the existence of a ‘personal ecological signature’ cutting across the various topical ecologies, influencing the respective learners’ choices across the ecology.

The second findings chapter widened its analytical scope to the entire sample, reporting findings from quantitative and qualitative analysis across the sample’s 24 research participants and their 121 topical ecologies. Leading up to the quantitative analysis a coding process had been undertaken to standardise the conceptions of ‘topics’, ‘interactions’, ‘resources’, and ‘contexts’ across the participants. Across each of the chapter’s sections, these original participant conceptions were reported as findings worthy of discussion. Analysis of ecological configuration metrics strengthened a hypothesis regarding the homogeneity of topical ecologies when compared to overall ecologies. Homogeneous topical ecologies, in terms of resource mix and contextual nuances, formed relatively diverse overall ecologies. The “ecological signature” unique to each learner, and their circumstances, was further highlighted by comparing the respective learners’ ‘choices’ in their ‘Education’ ecologies to their ‘choices’ across the overall ecology beyond these ‘Education’ ecologies.

The third findings chapter focused on outcome variables. It started by presenting the results of the research participants along the various stipulated outcomes. Then

moved to present the results of bivariate analysis relating those outcome variables to the ecological metrics defined and described in the second findings chapters. Finally, it ended with a report of the three themes that have emerged from the qualitative analysis of the reasons behind one of the outcome variables, namely satisfaction.

This chapter discusses these findings under five themes. The first three, grouped under one section, address the question concerning how learning ecologies of lifelong learners are shaped. The last two, grouped under a second section, address the question regarding the relationship between the outcome variables and the ecological parameters or metrics. Each of the two sections start by broad statements summarizing its main thesis. The subsections then follow elaborating, discussing, and explaining these theses tenets, and relating to the literature.

8.1. Shaping Ecologies

Perception shapes ecologies including and excluding topics, resources, interactions, and contexts. Perceived learning ecologies are constantly changing, in part in reaction to the perception itself.

The thesis found that lifelong learners are interested in, and usually pursue, multiple topics simultaneously. Their overall learning ecologies are diverse in the number of topics pursued, the number, types, and classes of resources, and the contexts of learning. Learners' individual topical ecologies are more likely to be homogeneous. Overall diversity on an ecological level is achieved through the amalgamation of several internally homogeneous, comparatively diverse, topical ecologies.

Learners seem to have some sort of ecological signature that influences their ecological choices. This ecological signature is not a simple manifestation of preferences, rather, it also reflects the *macro* contextual elements in which the learner is emersed. Developments on the learner level and changes in the macro context in turn can change this ecological signature influencing further their respective ecologies.

8.1.1. Perception defining ecologies

It can be claimed with relative confidence that the data collection approach has been able to capture the essence of the learning ecologies as conceived by the proposed conceptual framework. From the outset of the research, in its design stage, the approach had not been intended to capture the entirety of the 'ecologies,' rather a time-framed sample, from the perspective of the learner, that could somehow be

indicative of this entirety. The ecological parameters captured through the app are well aligned with those captured through triangulation, as shown in chapter 4. In fact, it is quite debatable whether the triangulating techniques (interviews, researchers' observations and notes, and application and reflection statements) would have been able to produce the same level of detail on the ecological parameters had they not been all used around a central diary-based data collection approach.

The findings chapters generally show how perception is an important filter for defining or bounding learning ecologies. The learner, as a human being, engages in a wide range of interactions, some of which are learning interactions and some of which are not, with a wide range of resources, some of which are learning resources and some of which are not, in a wide range of contexts, some of which are learning contexts and some of which are not. The key to learners' inclusion of a specific interaction/resource/context, as part of their learning ecology, is their judgement of it, or perception of it, as a learning interaction/resource/context. And on a higher level, humans 'learn' about a wide range of topics every day, if not every hour, and the key to the inclusion of a topic, and its associated interactions, resources and contexts, is the learner's commitment to, and/or perception of, it as a topic of learning.

Between the in-depth case studies, in the first findings chapter, and the qualitative findings reported from the wider research sample, perception, or judgement, have been shown to shape ecologies in four ways.

- Discounting even intentional learning interactions as ‘non-learning’ excludes associated resources, contexts, and topics.
- And on the other side of the spectrum considering a random, or regular, life experience as an incidental, learning interaction includes associated resources and contexts.
- Commitment to a topic, *a priori* or *a posteriori*, is usually the key to upgrading into an incidental learning interaction.
- Disregarding, or decommitment from, a topic leads to discounting associated interactions, resources and contexts.

(1) Discounting even intentional learning interactions as ‘non-learning’ excludes associated resources, contexts, and topics.

An example of interaction discounting is offered by Sally’s case, in the first findings chapter. Sally did not consider shorter and sporadic interactions with social and material resources ‘learning’ interactions, accordingly these associated resources, and even topics were excluded from her perceived learning ecology. One could argue that her Ph.D. topic, regardless her discounting of the short and sporadic interactions with her supervisors, is part of her learning ecology nonetheless, posing some refutational pressure on the premise of learning ecologies as perceived. This could be rebutted by referring to the dynamism characteristic, explained in forthcoming paragraphs, and the fact that to an extent the approach has indeed

captured her Ph.D. topic as an inactive ecology during the period of study. Beyond Sally, several research participants mentioned in the name generator survey, in the interview, interactions with social resources not included in their loggings and reflections, representing their 'perceived' ecologies. The interactions with those resources seem to satisfy the conditions of "who have you turned to for advice" and the "who turned to you for advice" during the course, the questions of the name generator survey, rather than their personal conditions of what constitutes a learning interaction.

(2) And on the other side of the spectrum considering a random, or regular, life experience as an incidental, learning interaction includes associated resources and contexts.

Examples from the other side of the spectrum are numerous. Interactions with a Holy book could be considered by many a spiritual or religious, rather than a learning, activity, making the Holy book, a spiritual rather than a learning resource. One-third of the study sample perceived the Holy book, and some of their interactions with it differently; they considered it both a spiritual activity and a learning activity. Multiple participants similarly logged movies, strangers, and random acquaintances as resources, having appropriated their respective interactions towards topics to which they are committed.

Although interactions are key for resource inclusion, they are not necessary, despite the 'accessed' condition. Some resources, as reported in the second findings chapter, have been logged into the App, however, they were included in no interactions. Considering they have been logged, these resources are convincingly part of the 'perceived' ecology, however, them having been 'accessed' could be disputed. I hold that their logging is one form of 'access'. For a learner to log a resource, into their consciousness or the App, some level of interaction must have taken place with this resource. This interaction might have been too short or shallow to include as an interaction, but as long as the resource lingers around in the consciousness of the learner it forms part of their perceived learning ecology. In fact, logging it is one form of reactivity with the process of documentation of the ecology. If it had not been documented, and subsequently reviewed, it would have withered out of the perceived learning ecology sooner.

(3) Disregarding, or decommitment from, a topic leads to discounting associated interactions, resources, and contexts.

The question then follows, learning ecologies are self-perceived according to which logged perception? Between the two findings chapters, I've reported multiple discrepancies between some of the ecological elements as captured by the App, through learners' loggings, and as reported by the learners in their reflective statements, their name generator surveys, and the interviews more broadly.

Examples of this include when Farrah mentions only three topics in the reflection statement, missing out on three logged into the App. As though she is filtering out those less active ecologies as less relevant. This might lead to the conclusion that the App has not been capable of capturing the ecology as perceived by the learner, considering the learner himself has contradicted his own logging. This however could be explained by the concepts of *dynamism* and the concept of *reappropriation*, or in this case, reconceptualization, also observed in this study.

(4) Commitment to a topic, a priori or a posteriori, is usually the key to upgrading into an incidental learning interaction.

A daughter's teacher, a daughter's school bus driver, and a total stranger, logged respectively by three different participants in the study sample as social learning resources, are not the standard resources one would expect in a learning ecology. As has been mentioned earlier, perceiving such a regular life interaction as a 'learning' interaction is the antecedent to perceiving some of the resources in this interaction 'learning' resources. Now speaking of interactions, beyond those discussions, with the teacher, school bus driver, and stranger, discussions with spouses have been logged by some participants and not others, although all married participants arguably had discussions with their spouses at least one time during the 8-week duration of data collection. What deems one discussion a learning interaction and the other not a learning interaction?

Commitment to the topics, *a priori* or *a posteriori*, is a necessary condition for perceiving a regular, or irregular, work or life interaction as an incidental, or even intentional, learning interaction. Some of these discussions were systemic, intentional learning interactions, entailing, for example, regular discussions of the online course's assignments and readings. Other discussions were ad hoc, incidental learning interactions, revealing insights, for example, on best practices for parenting. All discussions, however, were around topics already committed to (*a priori*) by the respective learners, such as 'Education' and 'Parenting'. One participant logged dealing with her car broken down the road as a learning interaction. She logged 'Car Maintenance' as a new topic into the App and edited it into 'Life Skills' in the interview, appropriating then reappropriating the interaction towards these topics, *a posteriori*.

Reflection (and other actions) shaping perception

Another 'learnification' factor, beyond commitment to the 'learned' topic, which is sufficient for the perception of many experiences as 'learning' experiences, comes reflecting after the experience. Reflection upon dealing with the car breaking down the road might have happened whilst logging, or after the experience, in reaction to the logging experience or process, or independently, but it happened nonetheless, taking this interaction, with the car and the stranger who helped, towards the newly committed to topic. One participant, mentioned in the second findings chapter, explicated this reflection premise, describing such regular life interactions as "an event and reflection" or "discussion and reflection".

In line with these findings, Kolb (1984) theorizes on learning from experiences through a learning cycle wherein learning moves in cycles; reviewing (or reflecting upon) experiences, concluding (or theorizing) upon review, planning to test those theorized hypotheses, and then moving back to action or experience.

Abstracting the reflection premise, noted above, leads to the claim that adding a step along the learning cycle would generally gear any of its activities more toward learning. This claim has some support from the reported findings. Watching movies has been logged by three participants, although probably experienced by a larger sum. Considering movies as ‘review’ activities, of the experiences of others, all participants mentioned extracting lessons (i.e. concluding or theorizing) into a dedicated notebook, or the App. From another perspective, in the cases of two of the participants, these movies had been reviews added to experiences, as they had been recommended by others to enhance the participants’ respective practices of ‘teaching’ and ‘using drama in education’. The only participant who had logged work-based learning logged a number of conceptual and planning discussions, with work colleagues or her manager, associated with projects she had actually been conducting, along the topics ‘Teaching Arabic’ and ‘Planning and Organizing’. The topical commitment in addition to the existence of this application opportunity, for trying things out, seem to pull these specific work discussions into the ‘learning’ realm. Sally’s case with her daughter’s illness provides a very intricate account of the power of movement along the cycle, along with commitment to the topic, in

regarding regular life experiences as 'learning' interactions. Sally, as detailed in the case, interacts with her daughter while ill observing symptoms and trying out medications, she reads about the disease and treatments, she discusses with doctors, and then she puts all her learnings into advice (plans) for friends and family facing similar illnesses with their kids. All these interactions, however, were not logged during our specific 8-week logging period because her kid, fortunately, did not get ill during the period.

Relating to the literature:

In the literature review, the distinction has been made between the whole set of resources and contexts, available in the world on a specific topic and the subset of those resources available to a specific learner. Another distinction has also been made between this subset of available resources, comprising the Zone of Available Assistance (ZAA), and the Zone of Proximal Adjustment (ZPA) which entails a subset of the former, filtered through the negotiation between the learner and other resources in her ecology, keeping only those resources from the ZAA which are developmentally appropriate (hence the word proximal) to the learner (Luckin, 2010). The definition of learning ecologies espoused by the study took on another filter, a third distinction, including only those resources and contexts, actually accessed by the learner (Barron, 2004). If the learner's perception is not the 'filter' in the first distinction, then it is certainly a filter in the second. The ZPA, formed through negotiation between the learner and others, certainly does not include those

resources or contexts, which fall beyond the learner's perception. This study has highlighted four ways in which perception acts as a filter, within or without the three distinctions mentioned above.

8.1.2. Ecological Dynamics and Reactivity

The time-framed samples revealed the respective learning ecologies, from the perspective of the individual lifelong learners, as dynamic constructs which are continuously evolving, in one respect in reaction to the perspective formed. It is important to note that although each of the characteristics is being discussed separately, they actually work together. Perception of a learning ecology changes over time, and the change is in part due to, or in reaction to, the perception itself.

Ecologies are Dynamic

The learning ecology as perceived by a learner is constantly changing. The duration of data collection for this research was eight weeks. The captured ecologies, represented by topics, resources and contexts, evidently changed during the period of the study. Topics changed at a slower pace than most resources. And topic-crossing contexts, were the most stable.

Beyond the Holy book and some of those resources utilised across multiple topics, resources were constantly changing, within the 8-week logging period. With an average of around two interactions per resource, individual resources, broadly, are

inconceivable to endure, actively, over more than a couple weeks. The Holy book, and the 'Intro to Education' course instructor do average around seven interactions over the logging period for participants. And although the latter disappeared from the perceived ecology, beyond the course duration, the former seems to have endured. Multi-topic resources such as the Google search engine, on the material side, and close connections, including family, friends, work-peers, work managers and life coaches, on the social side, supporting across topics, seem also enduring.

Topical ecologies were added, dropped, activated, or deactivated during the 8-week period. With the onset of the online course, the 'Education' topic represented an addition to many of the participants' learning ecologies. The logging period caught the final episodes of Adam's multi-year journey through his Psychology Bachelor's. The 'Psychology' topic, with its associated resources would have been beyond Adam's learning ecologies had the logging period started a couple of weeks later. Farrah constantly activated and deactivated topics; despite accumulating a total of six topics during the logging period, she never in any one week pursued more than three.

Contexts exhibited a behaviour opposite to that of resources. The majority of contexts, cutting across topics, endure in a learner's ecology, even beyond topics across which they cut, however, a minority of 'topic' specific contexts are constantly changing. Overall, the majority of learning among the sample's lifelong learners was conducted at home, which can be seen as a stable environment. Family and

friends' homes, third spaces, workplaces and formal education spaces are similarly enduring. Informal learning centres, mostly associated with specific topics or more precisely specific structured experiences, were constantly changing.

In accordance with these findings, longitudinal studies, asking retrospectively about a certain topic's ecology in a specific time and then asking again two years later, yielded two different ecologies in terms of resources and contexts (Barron, 2010). Change over time is generally accepted in the literature, evidenced by calls for longitudinal studies to understand how ecologies change or evolve, over time (González-Sanmamed et al., 2019; Sangrá et al., 2019).

Ecologies are Reactive

Part of this change of the learning ecologies is in reaction to the learner's perception of their learning ecologies. This perception is brought forward to the learner's attention, to be reacted to, by the App, any other form of documentation, or mere reflection.

Two specific mechanisms of reactivity have been specifically observed in this study, both of which are documented in the literature (Barta et al., 2012); motivation and (re)appropriation. Logging the learning was reported by some participants to motivate them to engage in learning, interacting with resources along their topics of interest, thereby allowing for more logging. Some participants highlighted that

reviewing the number of interactions they had accumulated over a couple of weeks, and judging them as few, motivated them to do more learning in the weeks that followed.

Exhibiting reappropriation, Adam, as mentioned in the first findings chapter, had engaged with a specific multimedia resource in hopes it would help clear out some of the issues covered in the 'Intro to Education' online course, when it did not help he reappropriated it towards the topic 'General knowledge'. Prior to, and whilst, interacting with the resource it was part of Adam's perceived 'Education' ecology. After the interaction, and upon reflecting on it, whilst or before logging it into the App, the resource moved to the 'General Education' topical ecology. Another participant exhibited reappropriation while logging an interaction; re-logging the movie, "The Ron Clark Story" towards 'English language' as a topic, after having logged it initially towards the 'Education' topic. In the interview she mentioned she re-logged it as she forgot to scribble certain comments on the interaction. As far as the picture thus far goes it seems like an act of reappropriation whilst logging, whilst bringing the resource to her attention through the act of logging. Going through her comments, however, hints she had these as primary and secondary intentions from the outset of the interaction. Again, this does not mean that it was not the act of logging that induced the reappropriating reactively, as the need for logging, and more broadly conceptualizing her learning in the systematic way required by the framework and the App might have very well induced this reappropriation. Farrah, on the other hand, explicated that the appropriation of the documentary she watched, as a

singular interaction, under the 'History' topic, was an afterthought, not reactive to the act of logging, but to the systemic logging experience.

Farrah had re-conceived her learning ecology wholistically towards the end of the logging experience, in the reflection statement, a re-perception window, discounting the 'History' topical ecology, along with three other ecologies. These re-conceptions, re-perceptions, re-appropriations are also apparent in a large number of un-connected, half-logged, or re-logged entries of topics, interactions, resources, and contexts. These re-conceptions, re-perceptions, and re-appropriations are features of perceived ecologies, constantly changing them, in reaction to logging, and nonetheless.

Reactivity has been disputed in the diary studies literature in terms of the significance of its effect, not in terms of its occurrence (Barta et al., 2012). This study has not been designed to contribute to the discussion around the significance of reactivity in diary studies, however, some elements of reactivity have been indeed observed as occurring. More important than occurrence however, is the premise that this reactivity is a feature of the learning ecologies of lifelong learners. On another level, reports about the motivational effects of logging one's learning align with the motivational effects broadly documented in diary studies (Barta et al., 2012).

8.1.3. Topical Dynamics

The hallmark of the detailed conceptual framework proposed in this thesis is the consideration of the multiple topical ecologies making up the overall lifelong learner's learning ecology. This study shows that studying a topic's ecology independent of other topics and the overall ecology fails to capture one of two defining features of lifelong learners' ecologies: dynamism and diversity.

Topical dynamism and trade-offs:

All of the study's participants expressed interest in more than one topic during the 8-week logging period of the study. Only two were not able to act upon those interests, confining their learning pursuit during the study period to the topic 'Education'. A few others marginally acted upon these parallel topical interests. The majority of the study's participants, however, actively pursued multiple topics simultaneously. The distribution diagram in section 6.1.2 implies the number of topics actively pursued flattens around three to four topics. Topical interests are pursued by interactions with resources. Limitations in time to engage in learning interactions limit the overall number of topics simultaneously actively pursued. Nader does actively pursue 10 topics simultaneously, however, time worked to his advantage giving him the least limitations among the sample group. As the youngest and most recent graduate amongst the sample group, Nader was the only participant to combine being single and unemployed.

Most learners worked around this time limitation with dynamic activation, suppression or downscaling and hibernation of topics. On a weekly level, Farrah's chart in chapter five, Figure 14, shows how the interactions in any single week never crossed the three topic limit, although she had logged interactions towards seven topics during the 8-week logging period. Beyond Farrah, and more strategically, section 6.1.3 shows how a number of participants had intentionally decided to suppress their activity on topics other than 'Education' considering the demands the 'Intro to Education' online course had put on their time.

Pursuing a topic in a less-active mode can serve several purposes. Some of those less-active topics entailed ad hoc, or opportunistic, interactions in topics of interest to the learner, however, to which the learner had not yet decided to dedicate considerable time. Other less-active topics entailed introductory and taster interactions exploring a topic, resource, or course to decide on later deeper engagement. Other less-active topics were purposely pursued in a less-active format (in terms of frequency of interactions in a given period of time), however, with the intention of accumulating progress over the long run.

Topical homogeneity building into overall diversity

Some topics, for some people, or at certain levels, beget certain resources and contexts. The results are homogeneity on a topical level and diversity on an overall level. Less active ecologies are by their very nature homogeneous, they do not entail

enough interactions or resources to exhibit diversity. The interesting finding, however, in this study was that even active topical ecologies are very homogeneous compared to the overall ecologies they build up into. Nine out of the ten topics, other than 'Education', pursued by the four learners portrayed in chapter 5 had very homogeneous learning ecologies. This homogeneity as shown in section 5.6 is observed at the level of sociability of resources, percentage of digitality of interactions, and the contextual parameters of learning, namely location and time of week/day.

Quantitative analysis, reported upon in chapter 5, went on to confirm this relative homogeneity. Locationally, 68 out of 121 topical ecologies (56.2% compared to only 5% in the case of overall ecologies) did not spread beyond one unique location. A further 31 out of the 121 (25.6%) spread to only two unique locations, one of which is always home. Temporally, a typical topical ecology spread over 4.3 of the day's hours, 3.2 of the week's days (compared to 12.75 and 6.75, hours and days respectively, for overall ecologies). Digitally, unlike overall learning ecologies, which always seemed to employ a mix of digital and non-digital learning, topical learning ecologies are much more homogeneous; pure digital or pure non-digital. Out of 121 topical learning ecologies 75 (62%) were homogeneous: 40 digital and 35 non-digital. Sociably, although homogeneity of resources, in terms of sociability versus materiality, were not observed on an overall level, as shown above, it was very protruded on the topical level, all in alignment with the findings of the first findings chapter. In terms of the diversity of resource categories, active non-education topical

ecologies entail an average of two categories of resources, compared to overall resources which boast an average mixture of six.

Relation to the literature

These findings, on topical dynamics, fill a general gap in the literature on the learning ecologies of lifelong learners, and a justified disregard to multiplicity of topics in the learning ecologies of other learning segments. It is important to note that studying the learning ecologies of lifelong learners without considering these topical dynamics might very well bring forth inaccurate conclusions concerning the homogeneity of ecologies and the preferences of learners. Yes, lifelong learners do exhibit specific preferences on the ecological parameters, as shall be elaborated upon in the coming section. However, these preferences are less sharp when observed on an overall ecological level.

Luckin's ideas on the filters on the skills and knowledge, within individual subject domains, do align with these findings on topical dynamics (Luckin, 2010). Luckin's 'Ecology of Resources' entails (a) skills and knowledge, (b) tools and resources, and (c) environment, mapping onto this study's topics, resources and contexts, respectively. Considering the abundance of available skills and knowledge specifics, within a specific domain, such as astronomy, filters define the actual learning ecology of a specific learner. Apart from curriculum, for formally pursued subjects, the learner's goal, motivation, and interest were all mentioned as filters for the skills

and knowledge defining a learner's ecology. Similarly, in this study, prioritization of topics, time management of activities, and motivation towards topics were all mentioned in section 7.3 as internal factors influencing the activity levels of learners in respective topics, hence the topical dynamics.

8.1.4. Personal Ecological Signature

Learners seem to have some sort of ecological signature that influences their ecological choices.

Lifelong learners seem to have some form of ecological signature, exhibiting certain preferences on the ecological dimensions, or on the configuration of resources and their patterns of engagement with them, across topics. The 'Education' topic offered common affordances to participants, yet the 'Education' topical ecology configured differently for different learners. Considering the similar affordances within which the ecologies took shape, these differences are attributable to some form of personal nuances, whether these are internal or external to the learner.

In section 5.6.1, comparing and contrasting the case studies on a topical level, ecological signatures were first implied. Adam, across his two active ecologies, and Sally, through her less active Psychology ecology, have retained the three directions of low sociability of resources, high digitality and centrality around home, and in-transit in the case of Adam. Dima and Farrah also maintained their bias towards non-digital across their active ecologies. Comparing some metrics, some

quantitative variables in section 5.6.2 confirmed the preliminary findings and necessitated more rigorous quantitative analysis across the wider sample.

The quantitative analysis confirmed the crossover of these preferences, however, with some caveats. On the contextual front metrics for digitality and patterns of temporal and locational engagement more or less map up between the 'Education' ecology and the wider ecology excluding 'Education'. And on the resource front the number of peers, multimedia, and software also significantly correlated between the two ecological units of analysis. One of the metrics measuring the temporal patterns, namely percentage of learning in the weekend afternoon, did not map up, increasing confidence in the statistics, as in fact this was the timing of the 'Intro to Education' course's online sessions. On the locational front, the percentage of learning at home, in informal learning centres, at family and friends' homes, and to a lesser extent in transit, mapped up. Work and university were specific to non 'Education' topics. Third spaces were expected to correlate, like family and friend's homes', as both were spill overs from home for those overwhelmed with responsibilities at home and requiring assistance with their kids, however this did not correlate. On the resource front, the online course had by design a great variety of resources, mandated or highly encouraged. This meant that a participant interacting with these resources might not necessarily prefer interacting with them beyond the 'Education' topic. Furthermore, the variety of resources afforded by the online course was not typical of the types of courses and structured programs reported by the research participants.

This ecological signature is not a simple manifestation of some innate preferences, rather, it also reflects the macro contextual elements in which the learner is emersed.

From one perspective learning at home, digitality, or at night when the kids were sleeping, were the only opportunities available to many of the research participants' considering their work and life obligations. However, learning at family or friends' homes and third spaces were alternatives to home sought out by some. Similarly, learning early in the morning was an alternative to the night sought by others. The contextual attributes of the learners' interactions seem to entail somehow a mixture of their personal preferences and their unique personal macro context.

Without proper analysis of the relationship between the contextual parameters and the resource categories it is difficult to discern whether the resource preferences, forming the ecological signature, are attributable purely to personal preferences, macro context or a blend of both.

These findings align with the work on communication patterns conducted by Saramäki and others (Saramäki et al., 2014). Saramäki et al discussed "social signatures" as (a) unique patterns of an ego distributing communication along alters, (b) varying from one person to another, hence the use of the word "signature", and (c) stable over time. Considering these attributes of the patterns Saramäki attributes them to time limitations and/or psychological (cognitive) constraints, without discern. This study also finds unique patterns of engagement with learning resources along contexts, which vary from one person to another. Stability in this study has been

observed across topics, rather than time. Due to the limited time-frame of this study it was not possible to discern how stable these patterns will be overtime. Building on the dynamic reactivity, discussed in section 8.1.1, developments on the learner level and changes in the macro context in turn might change this ecological signature influencing further the ecologies.

8.2. What are the effects of these variations?

Progress, satisfaction, and level of activity are three separate outcomes of learning ecologies. While not generally at odds with each other, they measure different dimensions of the impact of a learning ecology. Satisfaction is the most subjective, and is vulnerable to expectations. As such it is associated with the least amount of ecological parameters. Unlike satisfaction, activity level is measured exclusively at the overall ecological level, and progress is measured exclusively at the topical ecological level. Both level of activity and progress are associated with contextual spread and resource breadth. Beyond this each is associated with different parameters.

8.2.1. Dependent Variables for Quantitative Studies

A variety of outcome variables provide empirical research studies with a flexibility to measure what is important to the respective study. This study proposed and reported upon *Four* outcome variable categories; grades, learning progress, ecological satisfaction, and learning activity. The latter three are the most applicable generically to lifelong learning studies, and they measure different positive outcomes

which might be targeted by different people, at different points of time, or for different topics.

Grades:

Studying the learning ecologies of lifelong learners in their entirety renders taking on grades as the outcome variables difficult. As shown in the findings, adult learners do not pursue all their learning within graded courses and structured learning experiences. Grades however do positively correlate with two of the other outcomes variables, namely ecological satisfaction and level of activity. Those with a higher number of interactions, in their respective Education ecologies, were more likely to score higher grades. And those with higher grades were more likely to be satisfied with their ecologies.

Progress and Satisfaction:

Both satisfaction and progress are subjective measures. Satisfaction is measured on a topical level and on an overall level. The overall measure was shown to significantly positively correlate with an overall measure obtained as an absolute average of the satisfaction assigned to the respective topical ecologies .

Furthermore, it was shown to significantly positively correlate with an overall measure obtained as a weighted average of the satisfaction assigned to the topical ecologies, taking the relative level of activity as the weight. However, it was not identical to either. There were cases of participants who were not that satisfied with the ecologies of the individual topical ecologies yet satisfied with their overall

ecologies, and there were also cases of the opposite. The overall measure was, and should be, the measure used in studies of the learning ecologies of lifelong learners, as it measures more than the sum of its parts.

Progress was only measured on a topical level. It was primarily measured as the difference between the initial level of mastery and the final level of mastery at the end of the period of logging. This absolute measure significantly positively correlated to progress measured as a percentage of the initial level of mastery, and as a percentage of the gap between the initial level of mastery and the target level of mastery. And similar to the case of satisfaction measures above, the three progress measures were not identical. Progress as a measure of the initial level of mastery was useful in explaining the observed relationship between satisfaction and progress in the topic 'Education'.

Generally, a significant positive correlation between satisfaction and progress was observed. Learners who progressed in the topics of their interest were satisfied with the learning ecologies which supported them in bringing about this progress. Learners who were satisfied with their respective ecologies were more likely to perceive themselves as having progressed through their respective topics. However, as explained in chapter 7, satisfaction with the 'Education' ecology mildly negatively correlated with progress ($p > 0.05$) and strongly negatively correlated with progress as a percentage of initial level of mastery ($p < 0.05$). On further analysis a significant negative relationship was observed between the initial level of mastery and

satisfaction with the 'Education' ecology. Together this evidence suggests that the 'Intro to Education' course might have been too advanced for beginners, who despite having progressed along the topic felt challenged and dissatisfied by their respective learning ecologies.

Learning Activity and satisfaction:

Putting the hours into lifelong learning, given the constraints and limitations, is an agreed upon objective amongst lifelong learners. And as mentioned in the previous chapters, considering that learners actively and consistently manage the allocation of the time available for learning along the various topics they are interested in, level of activity has mostly been regarded on the overall level of the ecology. Evidence to the importance of the level of activity, and it being an objective, is dispersed along the qualitative analysis reported in the previous chapters. Expressing the reasons for their dissatisfaction in the interview, reported in both chapter 4 and 6, it was clear falling short of one's learning plans, in terms of dedicating time to learning, is a clear reason for dissatisfaction. This study, however, used the number of interactions as a proxy for the level of activity. It correlates well with the duration of learning, yet is more accurate and less prone to data input errors.

Despite being quoted as a reason for dissatisfaction, the relationship between the number of interactions and level of satisfaction with the ecology is convoluted.

Despite the recurring qualitative evidence, a higher a number of interactions dedicated to learning 'Education' is not associated with more satisfaction with the

'Education' ecology. And beyond the 'Education' ecology, learners are equally likely to be satisfied with their active and less active topical ecologies. Furthermore, on an overall level the learners with the higher overall level of activity, or number of interactions, do not necessarily have higher levels of satisfaction, and the opposite is true. Falling short of one's expectations seems to be key in aligning the qualitative and quantitative evidence. In section 7.1.5 the two participants with the lowest satisfaction scores seemed to have in common falling short of their intentions in terms of duration of learning.

Different objectives for different cases:

Satisfaction has been the most difficult to explain, amongst the lot, although it has been the most insightful. Progress, satisfaction and the level of activity are three separate outcomes of learning ecologies. Learning ecologies enable learning activity, this level of activity might bring forth progress or not, and finally learners are either satisfied with the support provided by these ecologies or not. And it is important to note that these variables are not generally at odds with each other. There is no trade-off between activity and satisfaction, neither between progress and satisfaction and certainly not between activity and progress. These different objectives which might be pursued by different learners for different topics, along their mastery journeys, or according to the demands posed by different topics. (A) Some participants have exemplified merely keeping some topics active, or alive, reacting to the pressures of the 'Intro to Education' online course, as mentioned earlier. (B) Topics at the higher levels of mastery are expected to progress slower

than the topics at the lower end of the progress continuum. At these higher levels of masters, progress would not truly capture the support provided by the learning ecology. (C) A learner with a stable level of activity on a certain topic might be more demanding when it comes to 'satisfaction'.

A business analogy might elaborate the relationship and utility of these three outcome variables. They, the outcome variables, are akin to revenues and profits, both of which are worthy business objectives. Higher profits are likely to bring in more revenues. However, if they have been achieved by generous spending on marketing and sales commissions they are likely to be disassociated from profits. They might even come at the expense of profits. Then shareholders/investors would hold different businesses accountable to different objectives at different points in time along their life cycle. Early on, rich on initial investment, shareholders might focus on revenues. Then as the business's market share increases attention would turn to profit. And on another level, shareholders might pressure different product lines within the same business on different objectives.

As mentioned in the literature review, few studies relate ecological variables to outcome variables, most of which are not in the lifelong learning segment (Sangrá et al., 2019). Proxies for topical achievement, akin to grades, have been the most prominent variables (Martin et al., 2014; Wong, 2013). Although useful these kinds of variables are not interoperable across studies as much as the outcome variables proposed and evaluated in this study. Furthermore, they are not flexible enough to

handle the expansive multiplicity of topics simultaneously by lifelong learners. In her work on adolescents' learning ecologies Barron has consistently used proxies for the level of activity (Barron, 2004; Barron, Walter, et al., 2010; Martin et al., 2014). Her approach was much more detailed, and specific to adolescents' learning, and the specific context of her studies, all of which again gives less flexibility and serves less interoperability.

8.2.2. Relationship between ecological elements and outcome variables

This section discusses the findings reported in this study with regards to the relationship between the ecological variables and the outcome variables. The section draws heavily on the findings presented in chapter 7 of this thesis. Table 20 below summarizes the findings reported in section 7.2. The headings beyond entail discussions of the relationship between each of the ecological parameters and outcome variables. The first three headings, carrying the titles 'satisfaction', 'activity' and 'progress', discuss and explain possible reasons for their relationship with the topical, contextual and general resource-related parameters, or none thereof. The next four headings, bearing the titles 'teachers', 'multimedia', 'family', and 'software and readings', discuss and explain the relationships between those categories and the outcome variables. A final heading relates these discussions and findings to the literature.

Table 20 Summary of the Outcome Findings in Section 7.2

	Overall Level		Topical Level	
	Number of Interactions	Ecological Satisfaction	Ecological Satisfaction	Progress
Number of Topics	Positive			

Breadth in Resources	Positive			Positive
Depth with Resources	Positive			Positive
Diversity of Resources			Positive	
Sociability	Negative			Positive
Temporal Spread	Positive			Positive
Locational Spread	Positive			Positive
Teachers	Negative		Positive	Positive
Family			Positive	Detailed
Peers				
Books				
Shorter Texts				Positive
Multimedia			Detailed	Negative
Software	Negative	Positive		

Satisfaction:

Although satisfaction is largely relative, having teachers and involving family in a specific topic seems to increase satisfaction for its ecology. Furthermore, multimedia increases satisfaction in active topical ecologies as opposed to inactive ones.

Beyond that no relationships exist. These relationships will be expanded upon in the subsections titled with the name of the resource categories below.

Here, however, the discussion focuses on the lack of relationships with the other ecological variables. Peers, as a resource category, is a case in point, elaborating some reasons behind this scarcity in relationship. Quantitatively, engaging with peers has not been significantly associated with any of the outcome variables. Yet, qualitatively it has been one of the most frequently mentioned levers for satisfaction. The ‘quantity versus quality’ and ‘relativity’ titles used to organize the qualitative

findings reported in chapter 6 seem to reconcile these quantitative and qualitative findings. The quality of the resources was not captured by the quantitative metrics used in this study. And quantity, up from 0 by engaging at least one peer, or relatively as a percentage of the makeup of the ecology, has been shown to be not a sufficient driver of satisfaction. Many participants who have reported engaging with peers were dissatisfied with the quality of their peers, or literally speaking, some of the 'qualities' of their peers such as preparedness and keenness to participate and cooperate. Beyond those a couple of participants explicated being 'not the social type' and a number of others seemed indifferent to engagement with peers.

For most of the ecological factors, the learners' expectations versus their reality seem to be the main discerning factor influencing satisfaction. On the peers level, some participants expected higher participation rates and more preparedness from their colleagues, with reality coming along to frustrate them, others had lower expectations and regarded their peers a blessing. Beyond peers, some participants accepted the topical dynamism, others considered it a major frustrater. Some participants looked at how they react to the contextual constraints and limitations and others viewed the existence of said limitations as frustrating. .

Level of Activity:

As the learner increases the number of topics actively, or less-actively, pursued they increase the number of interactions. In many instances topical pursuit is associated

with in a medium to long term, structured or unstructured learning experience. In which case the learner cannot really rush the learning by putting in more interactions. The only way to grow the number of interactions becomes adding topics. Boredom is another limitation on the amount of learning in any one specific topic per week. As the person adds topic, however, considering the wider limitations on their time, posed by life and/or work demands, the amount of learning dedicated to topics decreasing, exhibiting a form of diminishing returns.

Temporally, to increase the amount of learning a learner will need to spread their learning over more of the hours of the day and the days of the week. However, this holds true even given the very wide 8-slot classification (multiplying weekend and weekday by four times of the day: morning, afternoon, evening and night). Work and life demands compete with learning within each of these time slots, necessitating flexibility to achieve higher activity levels. Locationally, third spaces and family and friends' homes were sought out by the study's respective learners to deal with the childcare demands. Learning in-transit entails using alternatively dead time. Those who mostly confined their learning to the home environment with all its demands and interruptions were not able to put as much learning as their counterparts. Moving to third spaces and informal learning centres also presumably adds variety that kills boredom and encourage further learning in the home environment.

Quantitative analysis showed that there are limitations to how much depth, and frequency of interactions, can be achieved with a specific resource during an 8-week

during. Accordingly, within this limit, hitting the higher marks, consistently, is sensibly associated with higher levels of activity. Within this limit too, increasing the number of resources interacted with, breadth, is sensibly associated with higher levels of activity. Diversity of resources, along the categories studied does not seem to matter.

Material resources are especially associated with higher levels of activity. A higher percentage of social resources is associated with a lower level of activity. Social resources, agentic human beings, are understandably difficult to arrange an interaction with than material resources.

Progress:

Contextually, spreading the learning over several locations and temporally over the week is associated with greater progress. Progress does correlate to the level of activity. This relationship possibly explains the relationship between progress and contextual spread. If a higher level of activity necessitates contextual spread, given the discussion above, it might be true accordingly that progress requisites it.

On resources, increasing the breadth and diversity of the engagement with resources increases progress. Social resources are especially associated with higher progress. Breadth not only facilitates a higher level of interaction, but also accumulates layers of understanding and perspectives on topics. Diversity, following the same line of argument, ensures this breadth actually accumulated layers of understanding, perspectives and accommodates the different learning styles. From another perspective, diversity of resource categories also ensures most of resource categories associated with progress (discussed further below) do exist in the ecology.

Teachers:

Quantitative and qualitative findings aligned in highlighting the positive impact of teachers on satisfaction on a topical level. Topics in which learners engage with dedicated teachers, instructors or mentors score higher in terms of satisfaction than

topics in which teachers have not been involved. Teachers “motivate” as highlighted by many. They also guide through the complexities of the topics and sometimes, as suggested by some participants, provide a sequencing of recommended resources. In doing this guiding they achieve efficiencies that fast-track progress.

Progress here parts ways with level of activity. The higher the percentage of teachers in an ecology the lower the level of activity. From one perspective efficiencies in a learning ecology mean that the same level of progress could be achieved with less interactions, as they are optimized for progressing the learner along the topic. From another perspective, participants demanding courses, in section 7.3.1, are in essence demanding teachers, especially when considering their demand that these courses be live rather than recorded. It has been indeed noticeable that many participants do not pursue topics except within structured learning experiences, courses of sorts, involving teachers. As such a higher percentage of teachers in the ecology indicates a sort of dependence on teachers and would cause a lower level of activity in the case of inability to attend courses. Inability to join courses has been attributed to geographical, financial, and time limitations.

Multimedia:

Course recordings change the dedicated synchronous teacher, a social resource, into a digital asynchronous multimedia resource, a material one. Perceptively some participants, such as Adam and Angie, confused multimedia resources with

teachers. Others made the distinction taking synchrony to be the differentiating factor. Multimedia is extremely accessible and interactions with them are usually less taxing. When used to support other resources of learning they are positively associated with satisfaction. Interacting with at least one multimedia resource on a topical level is associated with a higher level of satisfaction. However, when constituting the main resource interacted with, as in less active ecologies, they have been shown to negatively correlate with satisfaction. Interactions with multimedia resources are also more vulnerable to distractions and the learner does not really get feedback on their understanding. As such, the higher the percentage of multimedia in a topical ecology the less the progress.

Family:

Quantitatively, involving family in an ecology has been found to positively correlate with satisfaction. Qualitatively however, family, in the form of spouses, parents and offspring, has been discussed as forces in the external environment. Offspring have been mentioned as a constraining factor for most, and not a constraining factor for one; Farrah, who's kids are older and relatively independent, emphasized that her teenage children were very supportive of her learning broadly speaking. Spouses and parents are mostly mentioned as supporters in childcare or not thereof. One participant complained their spouse was unsupportive of their learning broadly speaking.

The majority of family members logged as social resources were spouses, and the interactions involved discussing and reflecting upon content learned through interactions with other resources. Reconciling the quantitative and qualitative findings, involving a family member as a social resource on a topical level seems to signal a level of support higher than, and possibly including, childcare. Two participants had logged their children as social resources in topics pretty much associated with those children. In turning the children as the 'topic' of study and engaging with them as social 'resources' they transform from a constraint in the respective learners' ecology into an enabler.

The two forms of family involvement mentioned above place them as secondary resources, with whom primary resources are discussed, or the subjects (i.e. 'topics') of learning. As such involving family in the *resource poor* less-active ecologies has been shown to associate with lower progress. However, a higher percentage of family in the makeup of the active topical ecologies is associated with more progress.

Software and Readings:

Some participants classified websites as software, other participants classified them as other text. In this study websites were all re-coded into the other text category. 7 out of 8 of the participants who logged software, included 'Google search engine'. Of those some logged 'Google' instead of the articles and website accessed through it,

others logged 'Google' and the articles and websites accessed through it and others were inconsistent. This behaviour, of logging 'Google' instead of the articles and websites accessed through it, tentatively explains the negative relationship observed between the occurrence of the 'software' category, on an overall level, and the number of interactions. On the other hand, considering the 'software' category included three different types of software resources, it is difficult to explain the positive relationship between the occurrence of software and overall satisfaction.

Some participants also confused articles with other text. Articles were logged by all participants for the 'Education' topic, and very rarely beyond it. Accordingly, articles were merged into the other text category. As such shorter texts included articles, student handbooks, teaching notes, along with other forms of text short of being considered books by the participants.

Through the quantitative analysis, on a topical level engaging with shorter text, absolutely and relatively, is positively associated with progress. Books, shorter text, and multimedia are the main static 'sources' of information which bring forth progress. Books have not been associated with progress. And multimedia, as discussed earlier has a negative relationship with progress. A possible explanation, on comparing to the alternative multimedia, is that they require a higher level of engagement and attention which is more likely to push forth progress. A possible explanation, on comparing to the alternative books, is that its shorter nature brings about the progress which can be captured in an 8-week logging period, as opposed to books which might take longer for completion.

Relating to the literature

In alignment with some of findings discussed above concerning software and teachers, Luckin (Luckin, 2010) highlighted a filtering or referential role of more able partners (MAP). MAPs can be technologies (a category to which search engines belong) or teachers/mentors. And, among other things, they help the learner filter through the abundance of tools and resources available for learning. Barron et al (Barron et al., 2009) discuss seven role for parents, one type of family members, in the learning ecology of adolescent learners. Observing the roles played by spouses in this study, two more roles could be added for examination. First is 'Sounding Board' which differs from Barron's 'Project Collaborator' in them being simply available for discussing things over. Second is 'Time Saver' by performing tasks on behalf of the learner to allow them more time for learning.

Again, beyond these, the findings of this study are filling a gap in the literature on lifelong learners' ecologies, in terms of both their development and the outcomes associated with the variations of those learning ecologies.

9. Conclusion

Having discussed the findings of the study, this chapter concludes the thesis with contributions, limitations, reflexivity, implications, and further directions.

9.1. Study Contributions

9.1.1. Conceptual contribution

The thesis proposed a theoretically informed framework for analysing the cross-setting overall personal learning ecologies of adult lifelong learners. The framework conceptualizes lifelong learning as occurring when a learner pursues their topical needs and interests, through interactions with resources across contexts. It identifies three components that constitute a lifelong learner's ecology: topics, resources and contexts. Contexts, such as home and weekend mornings, usually host multiple topics, as opposed to resources which are generally topic specific (some resources do support multiple topics such as search engines, spouses and friends). The overall ecology is made up through the aggregation of multiple topical ecologies. The framework is novel in that it blends the recognition of multiple topics *and* contexts. Previous frameworks are either single-setting (Eradze et al., 2015; Normak et al., 2012; Pata, 2008, 2012) or single-topic oriented (Barron, 2004; Luckin, 2010).

Paving the way for interventionist and experimental learning ecology studies on lifelong learning, the model also elaborates on the ecological parameters and outcomes associated with such learning. As such it is filling a gap in the literature (Sangrá et al., 2019), as other *elaborate* models are either not suitable for capturing the complexities associated with adult lifelong learning (Martin et al., 2014) or do not

elaborate much on the achievement and affective outcomes of ecologies supported learning (Luckin, 2010) .

First, elaboration of ecological parameters:

To understand the varieties of learning ecologies in terms of topics, resources and contexts and the effects of these variations on lifelong learning relevant outcomes it is necessary to differentiate between various types of topics and resources, and the various dimensions of contexts and categories thereof. Topics have been differentiated according to the initial level of mastery as perceived by the learner.

One potential hypothesis, to be taken up in future studies, is that part of what defines the shape of an ecology is the initial of mastery of the associated topic.

Broadly resources were divided into social and material. Social resources were categorised into teachers (including mentors, instructors, and facilitators, which can also be differentiated in future studies), family (including spouses, children, siblings, and parents, which can also be differentiated in future studies), friends not sharing specific structured experiences, and peers sharing those experiences. Material resources were further categorised into books, shorter text (including articles, blogs, websites, teaching notes, and other forms of non-book text-based materials), multimedia, search engines, other software, hardware, and 'produced' materials (such as assignments). The divisions (material and social) were conceived through theory and verified by participants' conceptions. The categories reflect a dialogue between the categorizations proposed by others (Barron, 2006; Luckin, 2010; Martin

et al., 2014) and the perceptions of the participants in the study sample as coded and analysed by the researcher. Describing the patterns of an ecology, or its configuration, on this resource parameter entails noting breadth and depth of engagement with resources, the diversity of the resources interacted with (in terms of categories), and the specific composition in terms of the two grand divisions of resources or the underlying categories.

Digitality is proposed as a contextual dimension of the interaction, rather than an attribute of the resource. Time and location are the two other proposed dimensions. Time of the interaction included variations on the hour of day and day of week parameters, resulting in 8, 28, or 168 categories depending on the granularity of the hour and day partitioning. Location, for lifelong learners seems, according to the sample's data, to fall under one of seven categories: home, in-transit, third space, informal learning centres, family and friends' homes, work and university. Describing the patterns of an ecology, or its ecology, on this contextual parameter entails noting its level of digitality, spread over the temporal and locational dimensions and its specific composition in terms of times slots and locations inhabited. A fourth organizing dimension was proposed and that is structured and semi-structured opportunities, such as courses, book clubs, projects, and assignments. This is contextual in that it is not the resource interacted with, rather it entails one or more resources, allowing the learner to interact with them specifying, motivating, or mandating specific times and/or locations for those interactions. Beyond this conceptualization, this dimension was not developed in this thesis.

Second, elaboration of ecological outcomes:

Several non-topic specific outcomes have been proposed in this thesis, allowing flexibility to study the variety of learning ecologies. Considering the time-constrained nature of the adult lifelong learning pursuit, the overall level of activity has been proposed as an important outcome. An ecology ought to facilitate the ‘occurrence’ of learning interactions. Beyond this relatively objective measure, two self-appraised outcome measures have been proposed: progress (along the topics) and satisfaction (with the ecology). The first is to an extent an alternative to the objective measures of attainment used in other studies. The second is relatively affective; capturing the learner’s satisfaction with the process of lifelong learning, or more precisely the support provided by his self-curated personal ecology.

9.1.2. Methodological contribution

The thesis proposed a mobile-based evident contingent recording (ECR) approach to collecting data about learning ecologies. In this approach, interactions, the unit by which ‘accessed’ ecologies are created, are recorded by the learners as close to their occurrence as possible. The topic, resources, attributes thereof and contextual dimensions of each interaction are recorded while recording each interaction. The topics, resources and contexts aggregated over a period of time represent the ‘accessed’ and ‘perceived’ learning ecology for that period. The breadth, depth, diversity and composition of topics, resources and contexts could then be measured,

representing the ecological parameters. Satisfaction with the ecology and perceived levels of mastery, periodically gauged, along with the overall number of interactions, represent the outcomes associated with this ecology.

This approach has been shown in the thesis to render relatively accurate representations of the ecological parameters. The ecologies were captured as perceived by the learners. Perception shaped the captured ecologies in four ways:

- Discounting even intentional learning interactions as ‘non-learning’ excludes associated resources, contexts, and topics.
- And on the other side of the spectrum considering a random, or regular, life experience as an incidental learning interaction includes associated resources and contexts.
- Commitment to a topic, *a priori* or *a posteriori*, is usually the key to upgrading into an incidental learning interaction.
- Disregarding, or decommitment from, a topic leads to discounting associated interactions, resources, and contexts.

The time duration of the research captured the dynamic nature of the ecologies. This dynamism was shown to happen, in part, in reaction to the perception of the ecology as afforded by the data capture approach.

The study utilised a specific mobile application, Learnapp, iteratively designed and developed, to capture the above data as specified. This mobile application is intended to be made available to other researchers, however, as it stands its

features do not allow it to be used by multiple researchers in multiple parallel studies.

9.1.3. Empirical contributions

The thesis' empirical contributions can be broadly divided into sets: (1) explanations of how the learning ecologies of adults based in Cairo, Egypt, *develop* and (2) explanations of the relationships between the ecological parameters of the learning ecologies of this specific population and the *outcomes* of learning ecologies.

First, the development of ecologies

Multiple factors seem to shape the development of a learning ecology, and its specific configurations along the various ecological parameters, during a specific period of time. This thesis has focused on the elements associated with topics (as the inclusion of multiple topics into the conceptual framework is unique to this piece of empirical research). In summary, the factors defining the shape of ecologies are:

- Lifelong learners want and/or need to learn about a variety of topics
- Lifelong learners usually pursue multiple topics simultaneously
- Limited in time, lifelong learners continuously manage their activity levels in their topics of interest, allocating their time, effort, and attention
- Topical ecologies are relatively homogeneous in their ecological makeup compared to overall ecologies
- This homogeneity has been observed in sociability, digitality, locational spread, and temporal spread.

- This homogeneity on the topical level builds into diversity on the overall level, maintaining a clear exhibition of preferences
- Moving from topic to topic, aggregating into the aforementioned overall level, learners seem to exhibit an ecological signature
- This ecological signature has been observed:
 - In digitality
 - on the resource front in: patterns of engagement with peers, multimedia, and software
 - on the locational front in: proportions of learning at home, in informal learning centres, at family and friends' homes, and to a lesser extent in transit
 - and on the temporal front, broadly speaking
- This ecological signature is not a simple manifestation of some innate preferences, rather, it also reflects the macro contextual elements in which the learner is emersed.

Second, relationship between the ecological parameters and ecological outcomes

Progress, satisfaction, and the level of activity are three separate outcomes of learning ecologies. They are different objectives pursued by different learners for different topics, along their mastery journeys, or according to the demands posed by different topics. While not generally at odds with each other, they measure different dimensions of the impact of a learning ecology.

Progress, on a topical level, has been shown to be positively¹⁵ associated with:

- Breadth of engagement with resources, along diverse categories
- Sociability of resources
- Temporal and contextual spread
- Engaging with a teacher
- Engaging with shorter texts
- Engaging with a percentage of multimedia (negative)

Overall level of activity has been shown to be positively¹⁶ associated with:

- The number of topics simultaneously, however, with a diminishing marginal return relationship
- Breadth and depth of engagement with resources
- Temporal and contextual spread
- Sociability (negative)
- Engaging with teachers (negative)

Satisfaction, the affective measure appraising the ‘process’, is the most subjective, and is vulnerable to expectations. What one person values and needs in an ecology may very well be of low importance to another, and what one person expects of a resource, might be the beyond the dreams of another. ‘Relative’ quality of resources, and the interactions therewith, have been shown to be as important as the

¹⁵ The relationship is positive in all but the last parameter. A negative relationship has been highlighted between parentheses there.

¹⁶ The relationship is positive in all but the last two parameters. A negative relationship has been highlighted between parentheses there.

quantitative dimensions measured by the mobile-based data collection tool. Intrinsic and environmental factors, both external to the learning ecology, were shown to influence the satisfaction scores in many cases. Despite this relatively, some relationships between satisfaction and the ecological parameters were observed in the data and explained in the discussion. Overall satisfaction is not the weighted or the absolute average of topical satisfaction. Satisfaction, on a topical level, has been shown to be positively associated with:

- Diversity of resources
- Engagement with teacher or instructor
- Involving a family member
- Engaging with multimedia in active rather than less active topics.

9.2. Limitations

Beyond the limitations discussed in the methodology chapter of this thesis, there are a number of limitations in retrospect that are worthy of note when appreciating the aforementioned contributions.

First, the *large scope* of this doctoral project has been to an extent a limitation. Aiming to pursue both conceptual/methodological objectives and empirical ones entailed trade-offs. To name one example, clearly and repeatedly defining the terms used in data collection (such as ‘ecology,’ ‘material,’ ‘social,’ ‘software’, ...) to participants, whilst providing examples and guideline as to what each of those includes and excludes might have provided more accurate and reliable data necessary for the empirical contribution. However, a less definitive approach had been taken to probe through the data collection around the conceptions of the learners themselves, to feed into the conceptual and methodological objectives of the thesis.

Beyond the scope, the conceptual contribution, or more precisely, the empirical framework, arguably has a number of limitations. In light of the discussion in section 3.2.3, and the findings concerning ‘self’ logged as a resource in section 6.2.1, ideational resources pose themselves as excluded from the framework. On another level, and in light of the findings in section 7.3.2, and some of the conclusions presented above, and in contrast to other frameworks (Luckin, 2010), the conceptual framework lacks a detailing on the intrinsic and environmental factors affecting

learning ecologies. Furthermore, opportunities have not been sufficiently conceptualized.

The methodological contribution, the mobile-based evident contingent data collection approach, could be argued to have “perceptivity” and “reactivity” as limitations.

Failing to capture the aforementioned under-conceptualized opportunities could also be seen as a limitation. However, this is a limitation of the specific App used in the study, not the methodological approach more broadly. Another app, or another iteration of the app, could very well entail a field requesting the learner to log such opportunities.

Another limitation could be said of both the conceptual framework and methodological approach and that is failing to capture the relationships between the resources and each other, beyond the central learner. It is especially a limitation considering that one of the great affordances of both the ecological perspective (refer back to Bronfenbrenner’s meso-level relationship in section 2.2.3) and the network perspective (refer back to alter-alter relationships in section 2.3.2) is considering these dynamics between the elements beyond the learner. The app has attempted to capture some of these alter-alter relationship. It has captured them within interactions, in which the learner is involved, however, requesting the learners to specify the resource that led them to the resource at hand has pragmatically failed. This failure could be attributed to the overall problems of definitions, highlighted above, or to overburdening, which must be carefully treaded. Arguably

these alter-alter relationships, beyond the learner, could also be captured through two-mode network analysis (Crossley et al., 2015; Robins, 2015). Despite all this, I do believe that the inability to capture alter-alter relationships is a limitation to the conceptual and methodological contributions. However, it is also important to note here that, beyond this instance, the conceptual framework and the associated data collection approach do make use of the affordances, of both perspectives, in the appreciating the dynamics between the various ecological parameters. This, for example, although empirically excluded from this thesis has been discussed in the relationships between resources and contexts.

Empirically, the findings with regards to the relationship between the outcome variables and the ecological parameters are limited in having stopped at the level of correlations. This misses the effects of the ecological parameters on each other, or the ecological dynamics. Although some investigation has been conducted and reported into these cross variable relationship, such as the relationship between the number of topics and the number of resources in section 6.2.2., it has not been conclusive. Concluding these analyses along with multiple regression analysis for these variables would have solved this problem. However, owing to the limited sample size, previously mentioned, it was decided not to take these extra steps of quantitative analysis, as this sample size will stay a limitation on what could be said about those relationships, leaving multiple regression analysis to other studies. One could argue that the sample was indeed small for the level of activity, measured only on an overall ecological level ($n = 24$), however the sample size for Progress,

measured on topical level ($n = 121$) was sufficient. Yet, progress must be analysed taking into consideration the various initial levels of mastery. Theoretically and empirically, as far as primary analysis of the data at hand can tell, learners are expected to progress at different rates (measured over time or interactions) as they progress in the mastery of topics, with lower levels taking less to pass than higher levels. These multiple levels will render the sample size at each level too small for proper regression analysis.

9.3. Re-visiting the researcher's positionality

In retrospect, reflecting on the study and its contributions two elements must be re-visited concerning my position along this discovery journey.

Researcher as Lifelong learner

Beyond the doctoral project I am a lifelong learner. I want, need and do pursue multiple topics simultaneously. And immersed in the ideas of this thesis I constantly reflected on my learning ecology and on my ideas about learning ecologies.

Learning ecologies, as has been conceptualized and methodologically captured in this thesis, have not been purely shaped by my engagement with the sample's participants and the literature. My own experiences, and reflections on those experiences, have partially shaped those conceptions and methodology. Beyond the framework and methodology, these experiences and reflection must have also partially influenced my perception of the data and interpretations of the emergent findings. I cited my experience piloting the App and the positive impact it had on contextualizing the participants' loggings in the methodology chapter. I have also

attached in appendix F my own reflection statement on this logging experience.

These reflections entailed some conceptualizations on the framework level. And it is important to note that this piloting experience has not been the only personal lifelong learning experience possibly influencing this research project. Numerous other learning experiences, and reflections thereon, must have had their impact.

Researcher as Educator

In addition to being a researcher I have assumed the role of the adult educator in multiple venues. One of those venues, which in fact provided access to this study's sample group, is delivering 'Intro to Education' courses to interested learners based in Egypt. The implications of this role have been explained in the methodology chapter. Beyond this role, I lead a non-profit experimental micro school. My role there entails teaching teachers. Beyond this non-profit, I've been co-leading a learning and development business, which educates and trains managers working in large corporations. I work with human resource professionals designing programs to suit the needs and constraints of those managers. And then I personally deliver some of the components of those programs. Beyond those organizations I engage with multiple young adult learners as a mentor. And along all those experiences my conceptions concerning the learning ecologies of lifelong learners have developed. I have not only personally reflected, but also engaged with multiple of those adult learners and professionals, concerned with the learning of adults, around the concepts of this study. And again, these experiences, reflections and engagements must have had their impact on this study. I include, in appendix F, two reflective

notes on two different such interactions as examples of possible influences on this study.

9.4. Implications on Practice

One practical implication of this research is to use technology to empower the learners to better manage their learning ecologies. The contributions presented above have *in fact* inspired the design and development of an App to support lifelong learners in managing their learning ecologies. The App was developed building on the framework, the interaction-based data collection approach, the findings, and with the support of funds from an Oxford University-based IT Innovation Challenge. The App has not been yet released, however, should be released soon. Beyond this specific App, based on the contributions above, technology mediation could help lifelong learners with two specific affordances:

(1) Lifelong learners need tools to help them manage topical engagement. The findings showed that lifelong learners want/need to learn multiple topics usually simultaneously, they have limitations on their time and a multiplicity of factors affect their topical activity choices. Technology mediation might very well help (a) capture all their learning interests, (b) track their self-reported progress, (c) plan (and regularly revise) weekly time allocations to a number of topics.

(2) Lifelong learners need to visualize their learning ecologies. The findings have demonstrated that lifelong learners exhibit some form of ecological signatures. And that beyond this signature they change (possibly improve) their engagement with their learning ecologies in reaction to their perception of it. Lifelong learners develop their ecologies by interacting with resources across contexts. Technology mediation can help by (a) prompting the learner daily to log his/her learning interactions along the various learning topics, specifying resources and contexts of the interactions, (b) presenting visual reports and quantitative analytics on the ecological parameters, highlighting the ecological patterns for critical reflection.

Other practical implications are on the level of the lifelong program designers and administrators, whether in the corporate or recreational sectors, or beyond. Although this study has not investigated those programs, herein labelled ‘opportunities,’ per se, the findings on the relationship between the outcome variables and ecological parameters do offer important highlights for practitioners.

- i- declaration on other simultaneous topical engagements are important prior to embarking upon programs
- ii- although subjectively perceived, quality of the resources availed, and contexts encouraged or mandated, is as important as mere access
- iii- subjective conceptions of quality necessitate gauging such conceptions and perceptions
- iv- engaging family members should be designed for and encouraged
- v- it is important to diversify resources

9.5. Directions for Future Research

On the development of ecologies a number of questions have been raised by this study but remain answered. One theme grouping a set of those questions concerns the degree and forms by which structural and agentic forces come to play in shaping learning ecologies. One gateway to pursuing this theme through the proposed framework, and accordingly expanding it, is through the internal and external factors affecting the ecology. Although the internal versus external section (7.3.2) has been largely reporting on the participants reflections on satisfaction, it speaks profoundly to the question of structure versus agency in the shaping of the ecology. The conundrum, in the section, was whether environmental (structural) or intrinsic (agentic) factors contributed to the lack of satisfaction. On another level, however, the question was also whether external or internal factors result in the lifelong learner not being able to interact with resources, providing locational/temporal slots for learning, or the poor quality of these interactions. So in essence it is a question of whether internal or external factors led to the shape of the ecology as it stood in its 'realized' form for the learner. The learner was then either satisfied or dissatisfied with the realized form. And then they went on blaming internal or external factors. On another level, courses and other 'structured' opportunities are yet another form of structure. They structure both the resource and contextual dimensions of the ecology. Both opportunities and courses can either be availed to the learner or sought out, or even created or initiated by them. These distinctions are also gateways to elaborating the agentic and structural forces shaping ecologies.

Also on the development of ecologies, longer studies are recommended. These longer studies could explore dynamism and ecological signatures better with time series analysis.

On the outcome of ecologies, further studies, with bigger sample sizes, are needed to model the relationship between the ecological parameters and the outcome variables, taking into account the nuances of the topics pursued, personal preferences, and the contextual limitations. Such studies will guide both lifelong learning providers and self-directed lifelong learners on how best to achieve their lifelong learning objectives.

The empirical framework (detailed in chapter 3), data collection approach (detailed in chapter 4), and the specific metrics capturing the ecological parameters (detailed in chapter 5) have great promise to advance our understanding of the learning ecologies of lifelong learners. To advance our understanding, more studies are needed accumulating data along the framework and towards these ecological parameters across different data collection settings and contexts, and with larger sample sizes. The software application used in the study, once published for researchers to use, should facilitate this systematic accumulation of studies building up our understanding. The list below entails some suggestions and recommendations on using the empirical framework, data collection approach and/or the software application.

- Even if the research study's context is a specific lifelong learning course or program, researchers should expand the scope of data collection to include all the topics pursued by the lifelong learner beyond this specific course or program. The hallmark of the empirical framework is capturing the multiplicity of topics pursued by the lifelong learner and exploring the similarities and differences between the topical ecologies, thus further exploring the concept of ecological signatures.
- A research study need not necessarily be embedded within a lifelong learning course or program, or even a specific setting. In fact, taking samples of lifelong learners from beyond and across specific courses and program has the potential to address gaps in the literature concerning more non-formal and informal lifelong learning. The empirical framework is particularly suited to these alternative and daily-life contexts.
- Exploratory studies adopting the empirical framework, data collection approach, or software application should not provide participants too much instructions and examples on the level of granularity of topics, categorisations of resources, and variety of locations.
- On the other hand, experimental and quasi-experimental studies, and studies with very large sample sizes should take the time and space to provide extensive instructions and examples on these matters to allow for comparability of data input and require minimum researcher intervention, recoding the data.

- Instructions and examples should take place at the outset of the research. In addition to being provided to the participants in written form for later reference.
- The data collection software application, as it stands, does not capture structured opportunities (such as courses) to which individual interactions belong. In studies in which this specific software is used participants can be requested to specify these structured opportunities in the comments section while recording respective interactions. In studies utilizing other tools for data collection, specifying these structured opportunities should be required of the participants.

Lifelong learning is a necessity in these complex rapidly changing times, and there is yet much to learn about lifelong learning to help lifelong learners keep up with their demanding challenge. The learning ecologies concept promises to advance our understanding of lifelong learning. Furthermore, it promises to help lifelong learners navigate their way through the abundance of digital and non-digital resources and create time and space for learning amidst their respective demanding lives. This study proposed and evaluated an empirical framework and an associated data collection approach to pave the way for furthering our understanding of learning ecologies of lifelong learners. It is the hope that further studies build on these contributions, taking on the aforementioned suggestions and recommendations, taking us closer to a better world.

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