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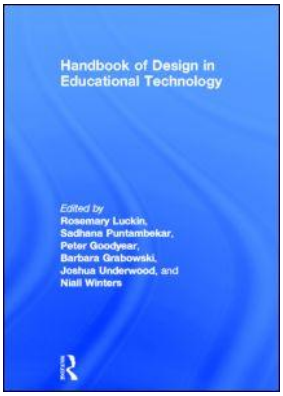

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The Ecology of Resources

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3

THE ECOLOGY OF RESOURCES

A Theoretically Grounded Framework for Designing Next Generation Technology-Rich Learning

Rosemary Luckin, Wilma Clark and Joshua Underwood

INTRODUCTION

William Gibson (1999) eloquently noted that our progress towards the future is 'not evenly distributed'. It happens in 'fits and starts' and in different places to different extents and at different times. The theories and frameworks upon which design activity is based must therefore be capable of engaging with the potential of the cutting edge, yet at the same time be capable of graceful degradation to meet the needs of those who are less technologically sophisticated. Participatory design methods can help designers to understand and address the reality of their beneficiaries, and a greater understanding of learners' contexts can inform this participatory enterprise. However, these methods need to be grounded on a sound theoretical foundation if they are to enhance learning and enable us to reap the full benefits of what modern technologies have to offer. For example, Web 2.0 and crowd sourcing can enable massive, global-scale collaboration, as employed by Galaxy Zoo (http://www.galaxyzoo.org/). Such developments in information-sharing and collaboration have the potential to provide the cognitive tools we need to enable us to act as 'epistemic engineers' and to build 'better tools to think with' (Clark, 2008) so that we can develop more effective educational practices:

> [We] self-engineer ourselves to think and perform better in the world we find ourselves in. We self-engineer worlds in which to build better worlds to think in. We build better tools to think with and use these very tools to discover still better tools to think with. We tune the way we use these tools by building educational practices to train ourselves to use our best cognitive tools better. We even tune the way we tune the way we use our best cognitive tools by devising environments that help build better environments for educating ourselves in the use of our own cognitive tools.
>
> (Clark, 2008, pp. 59–60)

In this chapter we therefore offer a theoretical framework for designing learning activities and technologies that takes advantage of the sophisticated knowledge and

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equipment that are increasingly available on a large scale. We present and discuss the Ecology of Resources model and associated design framework, which offer a way in which a learner's context can be integrated into the manner in which technology supports their learning.

THE THEORETICAL BACKGROUND FOR THE ECOLOGY OF RESOURCES

Context is a concept that is discussed across many disciplines and from a variety of perspectives. However, previous research into the manner in which context impacts upon learning has been largely limited to specific environmental locations, such as school classrooms. School classrooms are only one kind of context. Much of the literature about context and space is not specifically about education and learning, and yet it deals with issues, such as institutions and social interaction, that are also fundamental to learning. The proliferation of ubiquitous technologies has added to the complexity of the discussions about context. These technologies also provide an increasing impetus for the integration of research into the built environment and research into digital technology, or the blended physical and digital environment (see Keppell & Riddle, this volume).

> The proliferation of the microchip renders the everyday spaces of our existence alive, capable of interacting and reacting to our passage.
>
> (Kerckhove & Tursi, 2009)

Context can be viewed as a multiplicity, with individual people experiencing 'exposure to multiple "contexts" in time and space' (Cummins, Curtis, Diez-Roux & Macintyre, 2007). Context is 'perhaps the most prevalent term used to index the circumstances of behaviour' (Cole, 1996, p. 132). It requires that we interpret mind 'as distributed in the artifacts which are woven together and which weave together individual human actions in concert with and as part of the permeable, changing, events of life' (Cole, 1996, p. 136). This is a perspective that has roots in the work of Vygotsky (1978; 1986) and echoes through the literature on the situated approaches to cognition and learning (for example, Brown, Collins & Duguid, 1989; Brown, 1990; Lave, 1988; Lave & Wenger, 1991).

The Ecology of Resources model of context draws upon this research and provides a model and design framework based upon a learner-centered definition of context:

> Context is dynamic and associated with connections between people, things, locations and events in a narrative that is driven by people's intentionality and motivations. Technology can help to make these connections in an operational sense. People can help to make these connections have meaning for a learner. A learner is not exposed to multiple contexts, but rather has a single context that is their lived experience of the world; a 'phenomenological gestalt' (Manovich, 2006) that reflects their interactions with multiple people, artefacts and environments. The partial descriptions of the world that are offered to a learner through these resources act as the hooks for interactions in which action and meaning are built. In this sense, meaning is distributed amongst these resources. However, it is the manner in which the learner at the centre of their context internalizes their interactions that is the core activity of importance.

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> These interactions are not predictable but are created by the people who interact, each of whom will have intentions about how these interactions should be.
>
> (Luckin, 2010, p. 18)

This definition of context is integrated with an interpretation of Vygotsky's Zone of Proximal Development (ZPD), which is conceptualized as a context for productive interactivity. This conceptualization emphasizes the important role played by the society within which the learner interacts and, in particular, by the more knowledgeable, or more able, members of that society: lecturers, teachers, trainers and parents, for example. The need for further clarification and specification of the ZPD concept (Wertsch, 1984; Wood, Bruner & Ross, 1976) is addressed through its re-interpretation in the Zone of Collaboration. The Zone of Collaboration involves two constructs, namely: the Zone of Available Assistance (ZAA) and the Zone of Proximal Adjustment (ZPA). The ZAA describes the variety of resources within a learner's world that could provide different qualities and quantities of assistance that may be available to the learner at a particular point in time. The ZPA represents a subset of the ZAA that is deemed appropriate for a learner's needs.

The concept of the Zone of Collaboration is integrated with the description of context outlined above to form the Ecology of Resources model of context.

THE ECOLOGY OF RESOURCES MODEL OF CONTEXT

The Ecology of Resources model is illustrated in Figure 3.1. It develops the ZAA and ZPA concepts into a characterization of a learner along with the interactions that form that learner's context. Its full detail can be found in Luckin (2010). Here we describe it briefly to situate the presentation of the design framework and to ground the empirical examples that follow.

The resources that comprise a learner's ZAA embrace a wide range of categories, including: the knowledge and skills that are the subject of their learning ('Knowledge

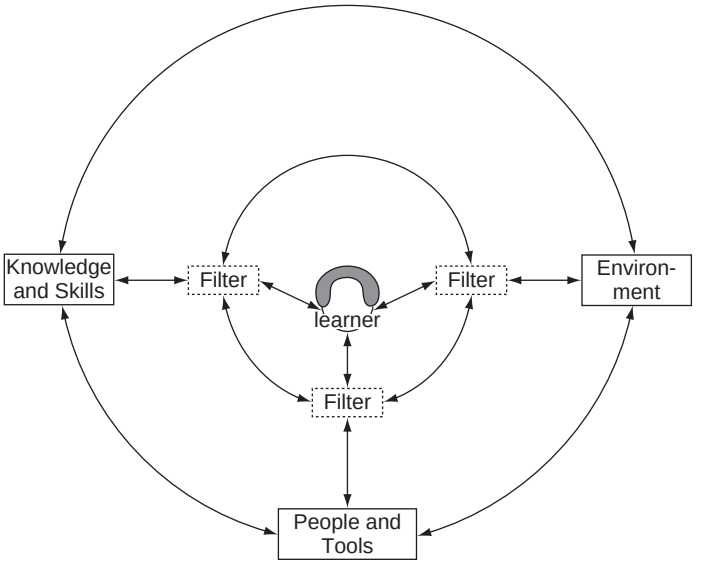

Figure 3.1 The Ecology of Resources Model (Luckin, 2010).

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and Skills' in Figure 3.1); the books, pens and paper, technology and other people who know more about the knowledge or skill to be learnt than the learner does ('Tools and People' in Figure 3.1); and the location and surrounding environment with which the learner interacts, for example, a school classroom, a park, a virtual world, or a place of work ('Environment' in Figure 3.1). To support learning, it is necessary to identify and understand the relationships between the different types of resource with which the learner interacts. In addition, it is necessary to explore the manner in which a learner's interactions with these resources is, or might be, constrained. These constraints are identified by the 'Filter' labels in Figure 3.1. For example, a teacher might filter learners' interactions with the world to focus upon and illustrate a particular concept. The teacher is probably only available during a class, or perhaps at some other times via email, and a learner's access to their environment is mediated by that environment's organization and any rules and conventions that apply to it. Filters can be positive or negative and may also be inter-related. The coherence of the learner's experience can be enhanced through careful consideration of existing relationships between filter elements and between individual resource elements and their associated filters.

In addition, it is also important to understand that all of the elements in any Ecology of Resources bring with them a history that defines them, as well as the part they play in the wider cultural and political system. Likewise, the individual at the centre of the Ecology of Resources has their own history of experience that impacts upon their interactions with each of the elements in the Ecology.

THE ECOLOGY OF RESOURCES DESIGN FRAMEWORK

The Ecology of Resources model helps to identify the forms of assistance available to a learner that make up the resource elements with which that learner interacts. The Ecology of Resources model could be viewed statically as merely a snapshot of the set of elements that describe a learner's ZAA and that can be 'optimized' by design and/or by practice. The model can also be viewed as a dynamic process of instigating and maintaining learning interactions in technology-rich environments. The objective of the framework presented here is to support the dynamic process of developing technology-rich learning activities. The aim of the Ecology of Resources framework is to map out the complexity of this design process so that it can be conducted with an enhanced awareness of the subtleties of a learner's context. This does not mean that the entire complexity of a learner's context can be taken into account within the process, merely that a greater understanding of the complexity enables the process, and the resultant technology-rich learning activities, to be more effectively situated. In particular, the design process supported by the Ecology of Resources framework identifies the ways in which technology, people and the learners themselves can best support learning. If the Ecology of Resources model and its associated design framework are to be useful to a design team, the overarching aim of their design process must be to engage with the learner's context as part of that process.

The Ecology of Resources Design Framework offers a structured process based upon the Ecology of Resources model of context, through which educators and technologists can develop technologies and technology-rich learning activities that take a learner's wider context into account. The process is iterative and has three phases, each of which has several steps.

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Phase 1: Create an Ecology of Resources Model to identify and organize the potential forms of assistance that can act as resources for learning. This comprises the following steps:

1. Brainstorm Potential Resources to identify learners' ZAA
2. Specify the Focus of Attention
3. Categorize Resource Elements
4. Identify potential Resource Filters
5. Identify the Learners' Resources
6. Identify potential More Able Partners (MAPs)
7. Iterate through Steps 1–6

Phase 2: Identify the relationships within and between the resources produced in Phase 1. Identify the extent to which these relationships meet a learner's needs and how they might be optimized with respect to that learner.

Phase 3: Develop the Scaffolds and Adjustments to support learning and enable the negotiation of a ZPA for a learner. Phase 3 of the framework is about identifying the possible ways in which the relationships identified in Phase 2 might best be supported or scaffolded. This support might, for example, be offered through the manner in which technology is introduced, used or designed.

Each phase and step should be completed through collaboration between beneficiaries and designers in a participatory design process. A full account of the framework can be found in Luckin (2010).

THE ECOLOGY OF RESOURCES DESIGN FRAMEWORK IN USE

The Ecology of Resources approach has been used in a variety of projects including: science learning in school, informal and formal learning in the developing world, home education in the UK, and adult foreign-language learning. In the following section of this chapter we present an example of the Ecology of Resources design framework in use. (Further detail about the Ecology of Resources design method can be found in the design section of this handbook and a fuller explanation of this and other examples can be found at http://eorframework.pbworks.com/)

Empirical Example

This example is drawn from a study completed with students and staff at a learning centre in the South East of England; this centre operates a self-managed learning (SML) process for 11–16-year-old learners in an 'out-of-school' environment. SML involves learning to learn within the context of the individual and the wider community. Consequently, learning within the centre is not formalized to the same extent as it is in more traditional educational settings. Nonetheless, many of the learners at the centre are seeking to gain formal educational qualifications. A key aim of the design process described in this case study was to *explore and model learners' contexts to identify ways in which available resources might best be used to support their learning needs.* These issues were addressed through the Ecology of Resources iterative, participatory design approach, in

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collaboration with learners and staff at the learning centre, as described in Phases 1 to 3 below.

Phase 1 Mapping Learners' Ecology of Resources

STEP 1—BRAINSTORMING POTENTIAL RESOURCES TO IDENTIFY THE LEARNERS' ZAA

Initial explorations with learners and staff at the centre revealed that, although learners had access to a wide range of technologies for both formal and informal learning, they did not find it easy to make connections between these technologies, their learning activities and the available spaces for learning. A preliminary generic ZAA was generated, based on a loosely framed design motivation, which focused on learners' selection and use of technologies on trips. This was later refined to supporting a trip to the Royal Observatory, Greenwich to learn about astronomy, as described in Step 2 below. The preliminary, widely framed, ZAA is consistent with the aims of the initial step of Phase 1 of the design framework; that is: to provide the widest possible ZAA, such that it may be revisited across several iterations to address multiple foci of attention. During subsequent iterations of the design process, Step 1 was used to produce a gradually refined ZAA, an extract from which is illustrated in Table 3.1.

STEP 2—SPECIFYING THE FOCUS OF ATTENTION

At the end of the first iteration of Step 1, the goal of the design process had been specified as: *Linking learners and technologies to specific trips.* A further set of iterations that moved between Steps 1 and 2 of the design framework was required to produce a sufficiently narrow and fine-grained focus of attention to enable progress to Step 3. The refinements that occurred through this process required further dialogue and interaction with participants and involved researcher participation in two trips organized by learners: one to a local farm, which focused on formal study and learning about biology and becoming a vet; and one to the BBC, which focused on leisure and learn-

Table 3.1 Refined ZAA after specification of the Royal Observatory trip Focus of Attention

Refined ZAA (Trip to Royal Observatory to learn about Astronomy)
Learners, staff from learning centre, siblings, peers, group/community rules, staff at trip site (museum guides, show narrators specialists, ticket attendants, shop assistants), other learners/visitors, trip site rules, interactive exhibits, simulations, models, trip site activities, trip site environment and facilities, weather, environment (indoors, outdoors, secure, unsecured, private), time, security, mobility, size, weight, money (mobile phone credit), posters, leaflets, flyers, books, digital information screens (adverts, exhibit information), mobile phones, batteries, memory cards, iPods or mp4 players, mp3 players (audio only), voice recorder, digital still image camera, digital video camera, combined still image/video camera, headphones (quality, size, comfort, ability to share—dual jacks), energy, co-ordination, information, filming (with video), reviewing photos of past trips/events (using iPod, mobile phone), discussing use of Internet to locate interesting facts, understanding technologies, newsletter (taking photos, writing notes, planning trip reports, sketching, drawing, recording information), activity ideas, watching downloaded or previously captured video clips, generating questions to ask *in situ* trip experts, communication (email, talk, text messaging, GPS networks sensors 'pushing' information, Flickr, Google Docs, blog, paper, pen, pencils, notepad, YouTube, Wikipedia, Google, digital video archives, films, DVDs, videos, Internet, computer literacy, media literacy, information literacy, maths, science, engineering, geography, history, culture, astronomy, learning models, process curriculum, Greenwich, Royal Observatory, Planetarium, Planetarium exhibits (information on universe, galaxies, stars, black holes, Milky Way, Meridian line, shows, video clips).

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ing through film studies and becoming a film producer. In each of these instances, the design team (comprising researcher, learners and learning advisors) was able to observe and discuss available resources, with a particular focus on the category elements and filters of the Ecology of Resources framework. With the increased understandings of the learner's learning context across multiple locations gained through this participatory design process, it was then possible to generate an appropriate focus of attention: *How can we support the learner to make appropriate selection and use of available technologies to learn about the Milky Way whilst on a trip to the Peter Harrison Planetarium at the Royal Observatory?*

STEP 3—CATEGORIZING RESOURCE ELEMENTS

The identification of a preliminary set of resources (the ZAA) enabled the generation of a preliminary Ecology of Resources model (Figure 3.2) that was subsequently further refined and reshaped through application of Steps 4–6.

Steps 3–6 are enumerated sequentially, but it can be useful to develop these steps in parallel, because identifying relevant filters and constraints requires a negotiation back and forth between resource elements and learner resources as well as consideration of the role of potential MAPs. It is not a matter, here, of trying to incorporate Steps 4–6 into the Ecology of Resources model generated at Step 3. It is, rather, a matter of identifying relevant resources and asking these follow-on questions at each step.

4—identify resource filters
5—identify learner's resources
6—identify More Able Partners

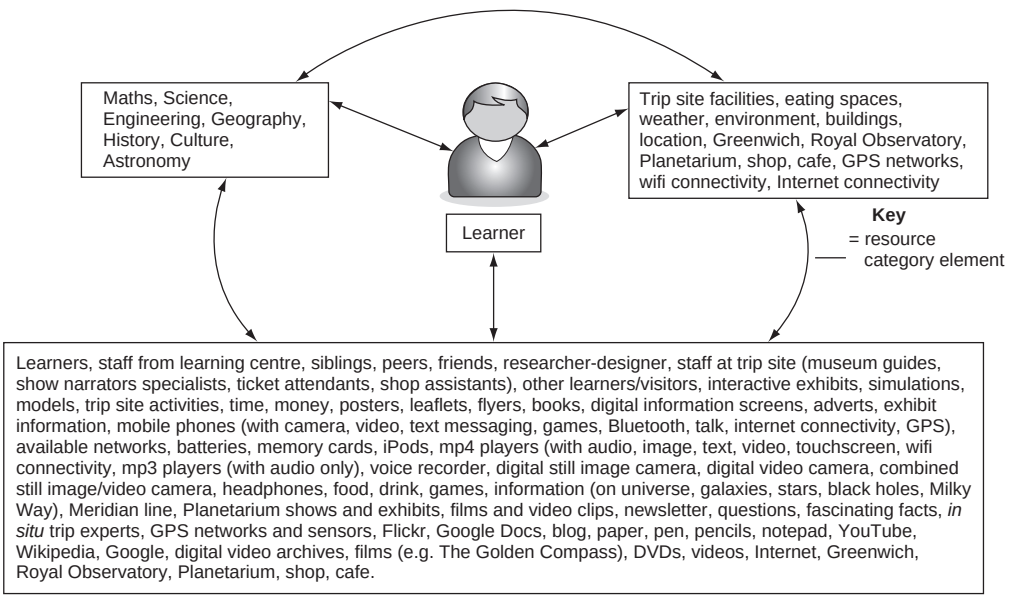

Figure 3.2 An Ecology of Resources model after an initial design iteration.

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STEP 4—IDENTIFY POTENTIAL RESOURCE FILTERS

Filters can act as constraints or as opportunities, each of which can have positive/negative qualities. In this example, for instance, learners who want to learn more about the Milky Way might attend the Planetarium where they will learn about the Milky Way as part of a particular scheduled show. The show as a resource is filtered by time (show times, length of narrative/visuals about the Milky Way), and by rules (no audio recording or photography allowed, meaning that learners must remember or record what they see in a different way). The ability to make notes about the show is filtered by ambiance. Lack of light in the darkened room acts as a constraining filter for writing. However, if, for example, learners have a mobile phone, backlighting enables note-taking. Listening to the narrator, the presence of the audience and respect for the rules of quiet listening when in company also act as a constraining filter on the learner's ability to use available MAPs as *in situ* resources. Some of these issues could be addressed in the design process, for example, by considering the use of GPS sensors, which 'push' information to learners' mobile phones at various locations, or, for example, the learner could opt to receive additional digital information about specific knowledge concepts via Bluetooth to their mobile phone. All of these things act as potential filters in the learner's interactions with her context. Table 3.2 illustrates resources and filters identified for the Planetarium trip example.

STEP 5—IDENTIFY THE LEARNER'S RESOURCES

Here, we must consider what resources and filters the learner brings to the situation. For example, some possible resources in this example were the learner's: coordination, curiosity, motivation/interest, existing knowledge, problem-solving skills, decision-making skills, planning skills, technical skills, learning models, learning styles, relationships, social skills, collaborative skills, communication skills, self-esteem.

Table 3.2 Resources and Filters

Resources (some of which are potential MAPs)	**Filters (can be positive or negative)**
Knowledge & Environment Astronomy, Planetarium show, interactive exhibits, simulations, models, digital information screens, information about the universe, galaxies, stars, black holes, Milky Way, film or video clips, audio commentaries, Planetarium learning workshops, Planetarium shop	Milky Way, design and layout of exhibit space, content/relevance/organization of exhibits, access (to show, exhibits, workshops, shop), Internet connectivity, network connectivity, language, location, Planetarium rules, time
People Learners, staff from learning centre, peers, researcher-designer, Planetarium show narrator, museum guides, Planetarium ticket collectors, shop assistants, other museum staff, other learners/visitors	Relationship, accessibility, time, location, existing knowledge, environment, confidence, opportunity, group/community rules
Tools Mobile phones, batteries, memory cards, voice recorder, digital still image camera, digital video camera, combined still image/video camera, headphones, mp3 player/iPod, DVDs	Connectivity, Planetarium rules, copyright, power, storage capacity, technology skills, availability, quality, ambiance (e.g. light levels, sound levels)

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STEP 6—IDENTIFY POTENTIAL MORE ABLE PARTNERS

We also need to consider who or what the MAPs are and what role they might play. For example, a range of potential MAPs can be identified in the scenario of the learner at the Planetarium who wishes to learn more about the Milky Way. Here, the MAPs could include: the narrator at the Planetarium show; the learning mentor from the learning centre who travelled on the trip; and/or peer learners and even technology capable of providing adaptive help.

Phase 2 Identifying Relationships and Filters

The aim of Phase 2 of the Ecology of Resources design framework is the identification of relationships and interactions that might influence the ways in which the resources, filters and MAPs may or may not be appropriated to act as forms of assistance for learners. The resources identified in this example are organized into groups according to the category elements and the relationships between the elements. Figure 3.3 illustrates a sample Ecology of Resources model of a learner's trip to the Planetarium incorporating resources and filters based on the preliminary output generated at Phase 2.

The model also incorporates arrows that highlight the relationships between these resources and filters. This Ecology of Resources model is still quite broadly framed, but can nevertheless be used and reused to consider scenarios and options and to explore the learner's potential interactions with resource elements. The relationships and filters framing available resources and potential MAPs can be made more explicit. Opportunities for cross-location activities can also be generated and made visible. Mapping a learner's interactions in this way can provide a preliminary model for considering ways

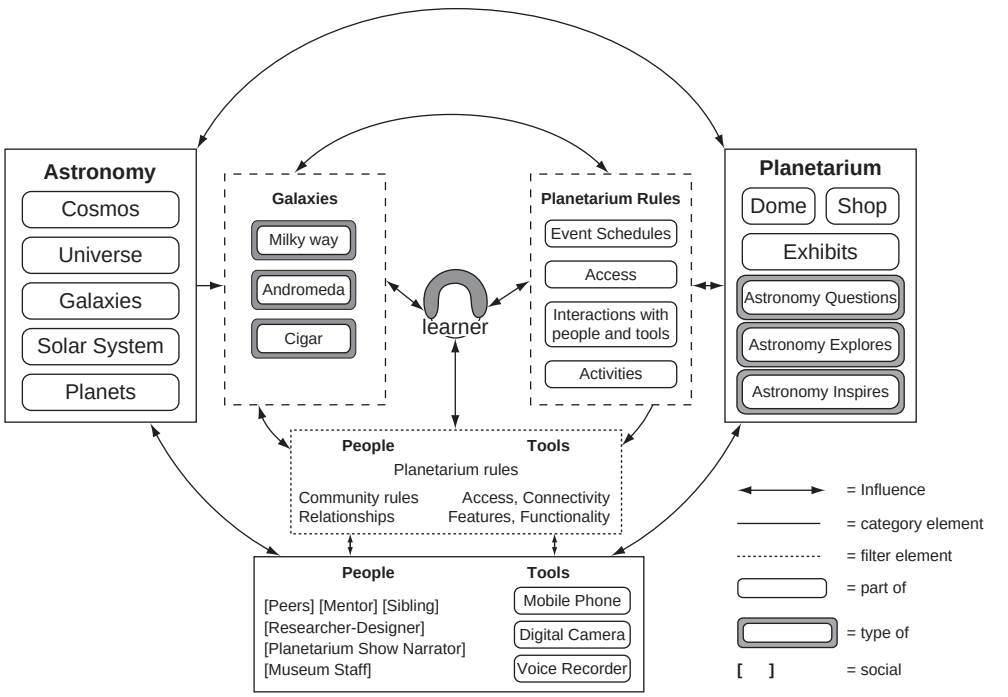

Figure 3.3 Ecology of Resources illustration for the Planetarium visit example.

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of developing effective scaffolds in both the learning process and the design process. Each of these resources and filters can influence any of the others, and it is perhaps only with this understanding that the value of the Ecology of Resource framework really starts to become apparent and the interdependency of the component parts of the learner's context begins to emerge.

Phase 3 Identifying Scaffolds and Adjustments

The research for this example was largely exploratory and focused on supporting learners' decision-making processes about appropriate and effective technology use to support their learning on educational visits and field trips. Phase 3 in this instance, therefore, focused more on identifying, for future iterations, potential scaffolding opportunities. For example, an adjustment to the rules framed by copyright has been made in relation to the Planetarium Exhibits hall, thus permitting learners to utilize their technology to capture data about their interests in astronomy, which they are later able to share with others, via Flickr, for example. A further example adjustment to this scenario could be made by making *in situ* provision within the Planetarium for visitors to share digital data captured in this way online, such as via a shared visitor website.

DISCUSSION

The Ecology of Resources model and its associated design framework offer a way to talk about learners and learning holistically—to sensitize designers to the range of interactions that constitute their contexts. The Ecology of Resources is based upon a definition of context that recognizes both the subjective and the objective nature of learners' experiences with the world, and the interconnectedness of all the elements with which they interact and that shape their understanding of the world. A learner's context is made up of the billions of interactions that they have with other people, with artefacts, and with their environment. These interactions provide 'partial descriptions of the world' that help learners to build understandings that are distributed and that are personally crystallized through a process of internalization. The Ecology of Resources is grounded in an interpretation of Vygotsky's Zone of Proximal Development. It conceptualizes the resources with which an individual interacts as potential forms of learning assistance. Emphasis is placed upon the role of More Able Partners, who help learners to identify a subset of resources called the Zone of Proximal Adjustment. It is interactions with the resources of the ZPA that will be of specific benefit to a particular learner.

The Ecology of Resources approach is an on-going project with many aspects, which are more complex than have been recognized to date. For example, the current instantiation of the Ecology of Resources model adopts an individual learner as the central unit of analysis. However, collaboration between more able and less able people is also a vital component of the approach, and this leads to multiple Ecologies of Resources centered on multiple different learners. These Ecologies interact with each other in complex and important ways to form networks of Ecologies. A second complexity is that of time. For example, a learning activity begins at a particular time and, whilst learning can continue throughout life, there is a time when a particular episode of learning, of which there may be many, comes to completion. These complexities need further development and are the subject of current attention that will further develop the theory, design, method and evaluation of the Ecology of Resources.

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