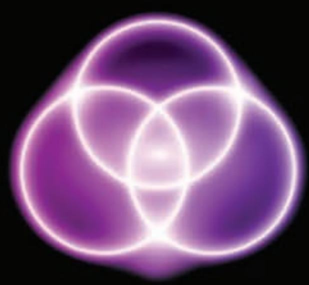
HANDBOOK OF DESIGN IN EDUCATIONAL TECHNOLOGY



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ROUTLEDGE

Handbook of Design in Educational Technology

The *Handbook of Design in Educational Technology* provides up-to-date, comprehensive summaries and syntheses of recent research pertinent to the design of information and communication technologies to support learning. Readers can turn to this handbook for expert advice about each stage in the process of designing systems for use in educational settings, from theoretical foundations to the challenges of implementation, the process of evaluating the impact of the design, and the manner in which it might be further developed and disseminated.

The volume is organized into the following four sections: Theory, Design, Implementation, and Evaluation.

The more than forty chapters reflect the international and interdisciplinary nature of the educational technology design research field.

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FOREWORD

The complex act of design is an enterprise engaged in by multiple disciplines across the Arts and Sciences from the formality of Engineers to the creative individualism of the Arts. There is much active debate about what constitutes design, how design should be done and who can participate in the process of designing. The purpose of the *Handbook of Design in Educational Technology* is to provide a practical guide for students and professionals that mines this complexity to extract and explain key approaches and tools. The design of educational technology is a young discipline that is evolving quickly. It is concerned with both designing the learning situation and designing the technology. It is also concerned with the people who will eventually use what results from the design process and with finding a way to engage them in the design process.

When the editors of this volume first started to discuss the type of book that we wanted to produce it was clear that we were embarking on a process that needed to mirror the subject matter of the product. The handbook would need to be carefully designed so that it would draw together a collection of chapters that were:

- interdisciplinary and that spanned social and technical expertise;
- reflective of advances in innovative technologies and methodologies;
- theoretically grounded to substantiate pedagogical integrity;
- carefully evaluated and reviewed to ensure quality; and
- contemporary so that the needs of modern designers, learners and teachers would be met.

We wanted to design a book that we would want to read and recommend.

There were few models on which to base our design, with little currently available to offer the reader a complete account from theory through to evaluation with descriptions of each step in-between. There were books that discussed research approaches to the use of technology to support learning, books that covered Instructional Design, manuals about the technical aspects of designing educational computing, from particular programming languages to methods and interface design. However, there was nothing that harnessed the social and the technical to offer readers a comprehensive account of the process of designing educational technology, a synthesis of recent research and expert advice about each stage in the process of designing from theoretical foundations to the challenges of implementation and impact evaluation.

The *Handbook of Design in Educational Technology* offers a compendium of 43 chapters written by an international community of authors that discuss the design of educational technology to support learners of all ages from within formal and informal education, and the work place. The technologies encompassed include mobile, ubiquitous and tangible as well as more traditional desktop and on-line computing resources. The volume is organized into four sections: Foundations, Design Methods, Implementation, and Evaluation. Each of these sections has been carefully commissioned, reviewed and organized by expert editors to provide a comprehensive tool for researchers and practitioners wishing to develop and use technologies for learning.

Rosemary Luckin
The London Knowledge Lab, London

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Part I

Foundations

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INTRODUCTION

Peter Goodyear

THE CHAPTERS

The chapters in this section of the handbook combine to provide some foundational ideas that can be used for thinking about design for technology-enhanced learning.

Ertmer, Parisio and Wardak provide a timely review of empirical research into how design gets done—who is involved, and how their goals, methods and contexts affect the processes of design for learning. It provides a useful overview of design, as well as a launchpad into an active, widely dispersed literature.

Keppell and Riddle open up a neglected dimension of design: work on innovative learning spaces. They use two case studies to explain how design principles can be used to align pedagogy and place. They also introduce the complicating but unavoidable challenges that arise when design needs to help with the integration of the material world, digital technologies and modern pedagogy.

Luckin, Clark and Underwood build on ideas of space, environment and situated activity in outlining the Ecology of Resources framework for design. The 'materialist turn' in educational research is broadening appreciation of the significance of networks of tools and artefacts in shaping human activity, including study activities. Luckin's model shows how complex learning environments can be subjected to analysis—to distinguish the many entities that affect learning—and how such analysis can inform and improve subsequent design work.

Reimann presents the theoretical roots of Design-Based Research and discusses how and when to apply the method in an aim to 'shed light on the processes through which technology gets interpreted and appropriated by teachers and learners'. This work highlights the importance of authentic educational settings and identifying the 'real needs' that technology should serve. A particularly interesting aspect of this work is the emphasis upon developing learning trajectories as an essential step in the design process.

Griffin, Bui and Care draw on major, contemporary efforts to define and assess '21st-century' capabilities to sketch some links between assessment of learning and design for learning. Combining criterion-referenced assessment of learning with Rasch modelling, the authors are able to show how actionable information about what students can do can be elicited and employed to (re)direct teaching. Design for learning needs to be able to design in opportunities for assessment.

Knowing what students are ready to learn can make a huge difference to pedagogical decisions—whether they are made by a human being, an adaptive machine, or a combination of the two. Knowing how students interpret the spaces in which they work, and how their activities are influenced by their surroundings, is vital if one needs to design supportive learning environments. Finally, being able to integrate thinking about design, environment, learning activity and outcomes is key to progress in this field.

1

THE PRACTICE OF EDUCATIONAL/ INSTRUCTIONAL DESIGN

Peggy A. Ertmer, Martin L. Parisio, and Dewa Wardak

WHAT IS DESIGN?

Design has been defined in a number of ways, with designers from various fields (e.g., architecture, fashion, and education) conceptualizing and defining their work in slightly different ways. Although design can be used to describe both a process and a product (Smith & Boling, 2009), in this chapter, we focus primarily on the process, or 'work', of design. Thus, design is defined here as a *goal directed, problem-solving activity* (Archer, 1965; Rowland, 1993), *which results in the creation of something useful that did not exist previously* (Reswick, 1965). Furthermore, we include the idea, proposed by Cross (2007), which describes design as occurring within a complex conceptual space, comprising both opportunities and constraints, which must be resolved in order to achieve desired and effective results. This definition, then, encapsulates the complex space within which designers work, while also suggesting that design often involves the resolution of competing tensions or priorities. In educational/instructional design, these tensions arise from competition between such things as learning outcomes, policy guidelines, graduate attributes, and students' needs and expectations (Bird, Morgan, & O'Reilly, 2007).

For many years, Cross has emphasized the importance of 'understanding the design process through an understanding of design cognition, or the 'designerly' ways of knowing and thinking' (2007, p. 41). According to Cross (2006, p. 22), 'design . . . encompasses unique things to know, ways of knowing, and ways of finding out about them'. By considering the work of educational/instructional designers as a 'kind of design', we are better positioned to see parallels between the processes, expertise, and languages of instructional design and those of other fields. This is supported by the results of Rowland's (1993) work, which highlighted many similarities between instructional design-focused studies and those in other design fields. Indeed, this similarity was initially noted by Simon (1969) over 40 years ago when he boldly proclaimed, 'design is the core of all professional training' (pp. 55–56). Moreover, recent research has demonstrated that much of what a designer does is common across design domains (Blackwell, Eckert, Bucciarelli, & Earl, 2009; Eckert, Blackwell, Bucciarelli, & Earl, 2010). For example, Eckert and colleagues (2010) found designers of different domains shared common stories about getting the right brief from the client and embraced descriptions of design as a 'conversation' with materials and tools. Interestingly, designers from different fields were able to comprehend each other even when unfamiliar terminology was used.

According to Rowland (1993), designing instruction is a subset of designing, in general, and as such, the general characteristics of design hold true for the more narrow instances of educational/instructional design. More specifically he defines instructional design as being '*directed toward the practical purpose of learning, i.e., the designer seeks to create new instructional materials or systems in which students learn*' (p. 87). This includes, then, the entire process of '*the analysis of learning and performance problems, and the design, development, implementation, evaluation, and management of instructional and non-instructional processes and resources intended to improve learning and performance in a variety of settings, particularly educational institutions and the workplace*' (Reiser, 2007, p. 7).

WHO PARTICIPATES IN DESIGN WORK?

In educational contexts, design work is undertaken by both multi-professional teams and solo designers. While some designers hold design-focused titles such as instructional designer, educational or curriculum designer, others engage in design work primarily as teachers, students, or library media specialists. In general, larger organizations often employ designers as part of their workforce, while smaller organizations tend to hire designers, as consultants, on an as-needed basis. However, regardless of whether designers are internal or external to the organization, their designs are influenced by the various contexts in which they occur.

DIFFERENT APPROACHES TO DESIGN WORK

Depending on work contexts, designers may function as members of a team or individually, and as external or internal to the organization they are serving. In large design teams, the division of labour often maps to individuals' skills; for example, an instructional design team might include a multimedia designer, graphic artist, pedagogy specialist, and so on. In a study of design-intensive industries, Dell'Era & Verganti (2010) found that innovators in design often collaborated with external designers to draw on knowledge diversity (p. 135).

Another common approach, participatory- or user-design, involves the end-user in significant design decisions (Carr, 1997). In general, end-users comprise those for whom the instruction is intended; in instructional/educational design, then, end-users can include teachers *or* students, depending on the specific design. Carr-Chellman, Cuyar, & Breman (1998) noted that this approach enabled all stakeholders to have a voice in the decision-making process, creating a greater sense of unity and project momentum. A good example of a participatory design approach is rapid prototyping (Jones & Richey, 2000) in which the end-users are involved throughout the design and development stages, resulting in a higher likelihood of successful implementation. However, increased time is required to educate participants about basic terminology and project-design techniques. Similarly, there is an interesting line of inquiry into the roles of *learners* as designers (e.g., Cameron & Gotlieb, 2009; Kolodner et al., 2003; Lim, 2008) and co-designers

(Könings, Brand-Gruwel, & van Merriënboer, 2010, 2011). Jonassen (1994) took this line of inquiry even further by arguing, 'We should take the tools away from the instructional designers and give them to the learners, as tools for knowledge construction, rather than media of conveyance and knowledge acquisition' (online, para. 5).

TEACHERS AS DESIGNERS

Recently, Goodyear (2010) emphasized the importance of broadening our conception of educational praxis to incorporate the concept of teaching-as-design. Hoogveld, Paas, Jochems, and van Merriënboer (2001, 2002) present a useful line of research in this area. For example, Hoogveld, Paas, and Jochems (2005) found that teachers who were trained in an instructional systems design methodology, the four-component instructional design model (4C-ID; van Merriënboer, 1997), performed better as designers than those who were not trained. In a more recent study, Bennett and colleagues (2011) interviewed 30 teachers across 16 Australian universities to examine various aspects of teachers' design activities including their teaching approaches, the contexts in which they worked, their approaches to designing, the key influences on their design activities, and the support mechanisms they accessed. Results indicated teachers frequently engaged in design and redesign of units, in both teams and individually, and were often given extensive flexibility in their design activities. In a similar vein, Lovitt and Clarke (2011) analysed several quality lesson plans to distil a set of generalizable and transferable design features that teachers tended to incorporate into their lessons. Components observed across lessons included a focus on group work and multiple ability levels, establishing challenges for students to grapple with, facilitating problem-solving, and instilling ownership in multiple interconnected content areas.

INSTRUCTIONAL DESIGNERS AS PROJECT MANAGERS

Design work often occurs alongside project management. Although the literature describes various models for instructional design project management (e.g., Gentry, 1994; Greer, 1992; Layng, 1997; Yang, Moore, & Burton, 1995), Van Rooij (2010) indicated a mismatch between the project management skills required of instructional designers in the workplace and the skills and knowledge taught in formal education courses. Indeed, Merrill and Wilson (2007) stated that ID graduates tend to spend the majority of their time on the job managing projects and training others to design instruction. As reported by Cox and Osguthorpe (2003), instructional designers in corporate and educational settings can spend up to 35% of their time in meetings and project management activities. Although the results might not generalize to other settings, this finding emphasizes the fact that project management can be a significant aspect of an instructional designer's work.

LEVELS AND CONTEXTS OF DESIGN

When conceptualizing phenomena, it is useful to consider the macro, micro, and meso contexts in which they occur (Goodyear & Ellis, 2008; Jones, Dirckinck-Homfeld, & Lindstrom, 2006). For example, before students enter a programme of study, curriculum designers work at the macro level to delineate a configuration of courses through which the students must progress. At the meso level, designers and teachers work to create individual learning tasks for students, and at the micro level learners design individual study practices. In theory, at least, design is practised at each of these levels when there is a need to achieve a desired goal, with the expectation being that design outcomes will be communicated across each level.

Undoubtedly, context shapes both the design process and design outcomes; what is often not considered, however, is how the design subsequently reshapes the context. Designers must frequently reflect on the design situation and respond appropriately. In education, such reflection involves gathering qualitative feedback from learners and quantitative feedback from formal course evaluations. In this way it can be said that the designer is in constant 'conversation' with the design situation (Schön, 1995). In the next section we describe, in more detail, the various factors that influence the design process.

WHAT FACTORS INFLUENCE THE DESIGN PROCESS AND HOW?

During the instructional design process, there are a number of factors that influence the process as well as the final product, including: (1) *people* (e.g., the client and/or audience for whom the design is being developed, the prior knowledge and previous experiences of the designer him/herself, and the knowledge and experience of production staff), (2) *contexts* (e.g., environments in which the design is developed and implemented, and (3) *expected learning outcomes* (e.g., impact of assessment and evaluation practices).

People-based Factors

CLIENTS: Impact of Designing for Diverse Clients

Designing for clients who are different from oneself requires a certain level of awareness and sensitivity (Ertmer, York, & Gedik, 2009; York & Ertmer, 2011). Clients can become quickly discouraged, or even upset, if designers downplay or ignore their needs or preferences (Ertmer & Cennamo, 2007). According to Summers, Lohr, and O'Neil (2002), although it is important for designers to communicate credibility, data, and feelings, in that order, clients will remember the information in the reverse order: feelings, data, and credibility. This is supported by the work of Dicks and Ives (2008), who reported that instructional designers consider 'building client relationships' as an important and significant aspect of their work. Designers can increase their credibility with clients by applying effective communication, interpersonal, and leadership skills (Summers et al., 2002). According to the participants in the Ertmer et al. (2009) study, designers should listen more than they talk and utilize responsive communication strategies that demonstrate sensitivity to clients' unique cultural, political, and interpersonal traits. Finally, it is important for instructional designers to avoid using technical language or instructional design jargon (Keppell & Gale, 2007), which typically serves to separate, rather than unite, clients and designers.

LEARNERS: Impact of Designing for Diverse Learners

Cultural differences between the designer and audience can greatly influence the design process. According to Rogers, Graham, and Mayes (2007), factors influencing the design processes include awareness of general cultural and social expectations, teaching and learning expectations, and differences in the use of language and symbols. For example, designers need to know how roles and responsibilities, such as student–teacher relationships, are defined by the cultural group for whom they are designing. Because symbols are interpreted differently in different cultures, designers need to avoid using languages and symbols that have the potential to be offensive to others. Even different conceptions of time and humour need to be considered. Based on the results of their work, Rogers and colleagues (2007) found that designers tended to be aware that cultural differences existed between themselves and the audience for whom they were designing but did not know what those differences were.

Johari, Bentley, Tinney, and Chia (2005), through a review of literature, identified at least eight factors that influenced how learners perceive the quality of instruction received, and as such, designers need to be aware of these. These factors include: (1) language, (2) educational culture, (3) technical infrastructure, (4) primary audience, (5) learning styles, (6) reasoning patterns, (7) cultural context, and (8) social context. According to Johari et al. (2005), language and culture are intertwined and impossible to understand independently. Furthermore, students from different cultures are likely to have strong ideas about how they learn best. For example, students from some cultures are not as familiar with group discussion and, thus, might not participate in these activities. For this reason, designers might need to provide familiar frameworks for the specific learners who will participate in their instruction (Gunawardena, Wilson, & Nolla, 2003). Still, there could be times when unfamiliar approaches are beneficial for introducing learners to new ways of learning and knowing.

In general, educational designers develop instruction in isolation (i.e., removed from the intended learners) with merely a list of learning aims to guide them. This often ignores the gap between the intentions of the designer when creating learning tasks and students' interpretation of them. One solution to filling this gap is participatory design, as described earlier, where students' perspectives are integrated into the instructional design process. Participatory instructional design can contribute considerable improvements to students' perceptions of learning and thus their learning outcomes (Könings et al., 2010, 2011).

DESIGNERS: Impact of designers' knowledge and experiences

Experienced designers bring a wealth of knowledge, gained from both formal education and personal experiences, to each design project in which they are involved (Ertmer et al., 2008). Designer-specific factors that influence how an instructional need is translated into instructional materials and/or activities include the designer's knowledge and use of instructional design theories and models and his/her previous experiences with the design process.

DESIGNERS' KNOWLEDGE: USE OF THEORIES AND MODELS

Based on the results of a number of recent studies (Ertmer et al., 2009; York & Ertmer, 2011), instructional designers appear to apply ID models, learned at university, to guide their practice (Martin, 2011), although they use them in a more fluid manner than advocated by formal ID textbooks (Ertmer et al., 2009). According to Ertmer and colleagues (2008), experienced designers create a mental model of the ID process, for example the ADDIE model, and use it to structure their design processes. Additionally, designers tend to use these mental models heuristically, as opposed to procedurally. Similar results have been reported by Romiszowski (1981) and Kirschner, Carr, van Merriënboer, and Sloep (2002): experienced designers use heuristics, or general guidelines, when making decisions under uncertain conditions (Dudczak, 1995). These heuristics are influenced by both prior conceptual knowledge and practical knowledge based on past experience. For example, the participants in the Ertmer et al. (2009) study reported that communicating successfully in design projects is critical; as such, most experienced designers have developed their own heuristics for communicating with clients.

In contrast to how instructional designers use ID *models*, results of a study by Yanchar, South, Williams, Allen, and Wilson (2010) demonstrated that designers, although generally favourable toward using *theory* in their designs, reported using only a limited number (e.g., Bloom's Taxonomy, Merrill's Component Display Theory, Reigeluth's Elaboration Theory). In general, the designers in the Yanchar et al. study described theories as being too abstract, rigid, or complex to apply readily in practice. Rather, similar to how ID models were applied, theories were used, more heuristically, to make sense of a situation and to guide decision-making.

DESIGNERS' EXPERIENCE: USE OF PRIOR EXPERIENCE

When solving design problems, instructional designers often use tacit or intuitive knowledge, derived from past experience (Winn, 1990). For instance, Rowland (1992) reported that expert instructional designers rely on their experiences as designers, whereas novice designers rely more on their experiences as learners. Furthermore, expert designers retrieve relevant information in the form of what Rowland calls 'templates' or 'mental models' that are triggered by a match to specific experiences. This is supported by the results of the Ertmer et al. (2008) study in which experienced designers narrowed the problem space of an unfamiliar problem situation using their personal experiences and unique 'frames of reference'. According to the authors, these frames of reference were built from an 'amalgam of knowledge and experience' (p. 28).

Hardré, Ge, and Thomas (2006) discovered a clear connection between an individual's background knowledge and his/her development from a student to an instructional designer. Thus, a background in teaching, instruction, or a related field supported the development of sophisticated design thinking, enabling students to create more complex designs than students with backgrounds in less-related fields. More specifically, students with backgrounds in teacher training or the military performed well in acquiring ID knowledge in comparison to a student with a background in philosophy who initially found it hard to integrate ID knowledge with his prior experience.

PRODUCTION STAFF: Impact of Knowledge and Experience

Another factor that can have an impact on how instructional design is translated into practice is the level of experience the instructional *developers* bring to the project. More experienced developers can produce instructional environments higher in both pedagogical and technical quality compared to developers with less experience (Boot, van Merriënboer, & Veerman, 2007). Furthermore, instructional design documents can be misinterpreted by novice developers (Boot, Nelson, Van Merriënboer, & Gibbons, 2007). This problem is exacerbated by the fact that most of those responsible for production are not professional developers and the job can be given to domain specialists or software experts who are not necessarily experienced in the production of instructional programs. In these situations it is recommended that the instructional designer divide the design document into interrelated layers and describe each layer in enough detail to guide both the developers and production personnel.

Context-based Factors

Designing for Diverse Implementation Contexts

Context is another important factor that shapes design work; instructional designers must be able to adapt their design processes and products based on where their designs will be implemented. Larson and Lockee (2004), categorized the different environments in which instructional designers work as: (a) business and industry, (b) higher education, (c) K–12 education, (d) government/military, (e) non-profit, and (f) health care. Significantly different values prevail in these various environments, which can make it particularly difficult for instructional designers to adapt to them, especially if they have gained little experience outside the higher education arena in which they received their formal training (Tasker & Packham, 1993).

Impact of Infrastructure and Technology

In addition to the type of organization being designed for, designers also need to consider issues such as the availability of technological infrastructure, speed of access, and even access to electricity for contexts occurring in underdeveloped countries or even in rural areas in some developed countries. With more educational institutions pushing to incorporate technologies into educational programmes, it is important for designers to determine how technologies will be used to facilitate learning. Each technology tool should have a stated purpose in the learning environment and should be linked to pedagogy (Mereba, 2003). A learning technology is a powerful tool, 'but one that may not be appropriate in all situations' (Cook, 2007, p. 39). Used inappropriately, technologies may actually hinder learning. For example, a study by Smith, Torres-Ayala, and Heindel (2008) found that some disciplines may not benefit from the use of technologies as a designer might imagine. For example, mathematics instructors reported that the use of Common Course Management Systems (CMSs) did not work well for incorporating mathematical diagrams and notation systems into instruction and, as a result, placed extraneous cognitive load on the learners.

Impact of Content

The type of content being designed, as well as how it will be delivered, also play important roles in the design of educational environments. For example, Jin and Boling (2010) discovered that instructional designers often included images in their content in order to attract attention, reduce cognitive load, facilitate understanding, assist in learning transfer, build mental models, and increase memory. However, learners perceived the meaning and purposes of these images differently. The study found that learners' perceptions were in congruence with the designers' intentions for only half of the images analysed.

Another challenge exists when designers try to design instruction for a highly interactive and/or constructivist environment using a very linear, structured model. According to Der-Thanq, Hung, and Wang (2007), learning activities often do not match the desired learning outcomes because there is a lack of design tools and methods to support new learning approaches. For example, designers may often use traditional design methods, such as task analysis, to design non-traditional activities such as collaborative projects. To solve this challenge, designers may need new design tools and methods to support progressive pedagogies and learning theories.

Outcomes-related Influences

Designing with the End in Mind: The Impact of Assessment and Evaluation

According to Reeves (2006), eight factors need to be aligned to ensure the success of any learning environment. These factors are: (1) goals, (2) content, (3) instructional design, (4) learner tasks, (5) instructor roles, (6) student roles, (7) technological affordances, and (8) assessment. According to Reeves, among these eight factors, assessment is the most commonly misaligned factor.

Assessment is often confused with evaluation. Whereas *evaluation* comprises judging the effectiveness of educational programmes and products, *assessment* involves measuring student learning (Reeves, 2000). However, often the same data are used for both tasks. For example, the results of final examinations are used to assess students' learning but can also be used to measure the success of the programme (Reeves, 2000).

The Impact of Assessment on Design Practices

When designing instruction, it is important to ask at the outset how the resulting design will have an impact on the learners. In other words 'how will you know they are learning?' (Reeves, 2006, p. 307). The design of assessments is an important factor in the design process because it influences the actions and approaches learners take towards studying (Struyven et al., 2005). For example, formal examinations, mostly consisting of multiple-choice questions, are common in student assessment because they are easy to implement. However, these methods encourage a surface approach to learning, with a focus on memorizing facts and demonstrating static knowledge, rather than the application of critical thinking skills (Tian, 2007). Herrington and Oliver (2000) recommended integrating assessment with authentic learning tasks so that assessment comprises the results of investigations, not formal tests. Technological affordances present new opportunities for rapid and radical changes in assessment, however, it is essential that assessment measures what is important, not what is easy to assess (Reeves, 2006; Griffin et al., this volume).

Sluijsmans, Prins, and Martens (2006) recommended that assessment, particularly summative assessment, be integrated into the learning design by engaging students throughout the learning process in authentic tasks, which gradually become more complex. By successfully completing increasingly complex tasks, learners master the required knowledge and skills. This idea is based on the whole-task approach (Sluijsmans et al., 2006) in which the first task is the simplest version of the tasks that professionals encounter in real working environments. Subsequent tasks represent more complex versions until the final task comprises the most complex task that professionals encounter. In an example given by van Merriënboer, Kirschner, and Kester (2003), students are given an assignment to search for literature. The first task involves searching for clearly defined concepts, which will lead to a smaller number of articles. Subsequent tasks involve searching for complex undefined concepts where a larger number of articles are available and students are required to search larger databases.

The traditional individualistic types of assessment practices have been challenged by various forms of student-centered, collaborative or cooperative activities that facilitate student mastery of a variety of 21st-century learning outcomes (e.g., collaboration, problem-solving—*see* Griffin et al., this volume). One example of this type of assessment is peer assessment, which has demonstrated great learning benefits for both small and large groups of students (Ballantyne, Hughes, & Mylonas, 2002). The implementation of peer assessment in groups is a challenge to designers but if done right has numerous learning benefits for students. In particular, designers need to be aware of factors such as the need to judge students on collective rather than individual efforts, a shift away from defined learning outcomes to dynamic learning processes, and the need to understand how results should be used—that is, to support or modify another grade, rather than as a graded assessment itself (Boud, Cohen, & Sampson, 1999).

Recently, the function of assessment has evolved from being an event at the end of learning programmes that measure 'what' has been learned, to a series of events aimed at monitoring learning and focusing on 'how' students transform information into usable knowledge (Hagstrom, 2006). In real-world situations, once students graduate, they must be able to judge the adequacy of their own learning. To become life-long learners, students need to become adept at self-assessment and to be able to make judgements about their own work and that of others (Boud & Falchikov, 2006).

Peer assessment and self-assessment give greater autonomy to the learner. According to Taras (2002), 'we need to implicate students as active participants and protagonists in the assessment process' (p. 508). This type of design changes the relationship between designers and users including students, teachers, and trainers.

The Impact of Evaluation on Design Practices

According to Williams, South, Yanchar, Wilson, and Allen (2011), the instructional design literature rarely, if ever, focuses on the actual evaluation activities carried out by designers. Furthermore, conducting formal evaluations is generally not encouraged by the designers' own organizations or disbursed by the clients. Project constraints such as budget and deadlines often push evaluation to the bottom of the priority list. As a result, instructional designers report spending less than 2% of their time engaging in evaluation activities (Cox & Osguthorpe, 2003). Similarly, Hoogveld and colleagues (2001, 2002) found that teachers spent little time on the evaluation stage of design.

Some instructional designers feel that it is important to deliver their work on time rather than spend extra time evaluating their designs. For example, one of the participants in the Rogers et al. (2007) study explained, 'there might be a desperate need for HIV training or training for refugees where people don't want to wait until it is perfected' (p. 208). The same participant elaborated,

> The ideal situation is that you create a pilot testing phase that is planned into the development process when you are preparing the materials for the first time. Now, often this kind of pre-test gets squeezed out because you never have enough time to do what you want to do even if you want to do it' (p. 208).

Williams and colleagues (2011) reported that instructional designers do conduct evaluation activities but in less formal ways. For example, instructional designers used the principles of evaluation in their work to integrate assessment into learning experiences to encourage students to apply what they had learned. This supports the idea, alluded to earlier, that the results of student assessments can be used to evaluate the success of instructional design programmes or products (Reeves, 2000).

Communicating the Design

Communication plays an important role in the design and development of instructional systems. According to Liang (2000), communication is one of the top four competencies of successful corporate professionals. The 31 participants in the York and Ertmer (2011) Delphi study identified effective communication, in visual, oral, and written form, as a key component in the instructional design process. In complex projects, instructional designers need to communicate different types of information to different stakeholders including managers, producers, instructors, subject matter experts, and software programmers (Boot & Kremer, 2006). According to Derntl, Figl, Botturi, and Boot (2006), misinterpretation can be reduced by representing ID products and processes using formal design languages: 'A design language is a set of concepts that support structuring a design task and conceiving solutions' (p. 1216).

An example of a formal design language, not bound to the instructional design field, is the Unified Modeling Language (UML) used to analyse, specify, and design software systems. The language has been in existence since the late 1980s and has been refined through practice (Booch et al., 2007). Using formal design languages entails practical and theoretical benefits for instructional design, such as improving communication within design teams; improving communication between designers, producers, and clients; promoting innovation in design; easing the integration of theory within designs; improving design sharing and comparison; improving designer education; and, automating design and production tasks (Gibbons, Botturi, Boot, & Nelson, 2008).

In instructional design, however, there is a lack of formal standardized languages that are understood and interpreted similarly by both designers and producers (Boot, van Merriënboer, & Theunissen, 2008). Still, lessons can be learned from other areas that have utilized design languages and notations systems successfully. For example, dance choreography has a clear standardized notation system that must be agreed upon and understood by the choreographer, the dancer, the stage manager, and other production staff members in order to synchronize participants' actions and produce a dance performance (Waters & Gibbons, 2004).

Design languages are mostly expressed through notation systems, which usually appear in visual form, using text and diagrams. Conole (2010) identified seven types of representations in instructional design: (1) textual summary, (2) content map, (3) task swimlane, (4) pedagogy profile, (5) principles matrix, (6) component map, and, (7) course map. The type of visual representation used is dependent on its purpose. For example, mind maps and models can be used for conceptual representation. Some formal instructional design languages utilize visualization in order to enhance team communication, improve design, and contribute to the development of high-quality instruction. Regardless of form, visualization allows designers to externalize their thinking, thus making their ideas available for reflection and better understanding (Botturi, 2008). Visual form is mostly preferred because it is instantly recognizable, thus encouraging interpretation, abstraction, and the simplification of complex ideas (Hokanson, 2008). Furthermore, visualization enables further development of design ideas by making them available for reflection, criticism, and reaction.

E^2ML (Educational Environment Modeling Language) is an example of a visual language used in the design of educational environments (Botturi, 2006). E^2ML is a tool used to develop a visual representation of instruction that all stakeholders in a design process can similarly comprehend. It has a limited number of basic concepts supported by a visual notation system and can be used at any stage of the design process. The use and potential effectiveness of the language was tested in an experimental setting with 12 designers from different disciplinary backgrounds (Botturi, 2005). The 12 designers agreed that E^2ML was potentially powerful, flexible, and adaptable to different design situations. Interestingly, the designers stated that they usually developed a mental, but unexpressed, image of the course, and that using a visual language such as E^2ML would help them organize their thinking, speed-up collaboration, compare different design solutions, and help maintain overall consistency in their designs (Botturi, 2005). Figure 1.1 presents an example of how E^2ML can be used to illustrate dependencies in an instructional programme. The aim of the dependencies diagram is to show that learning activities are connected in deep and meaningful ways, which can, then, enable designers to control the effects that local changes can have on whole environments.

SUMMARY

The foundational design literature portrays design in educational technology 'as a highly systematic, problem-solving process, executed by individuals who specialize in portions of the larger process, and informed by empirical evidence gathered throughout the design process' (Smith & Boling, 2009, p. 13). Yet, in practice, design work is rarely as systematic as portrayed, as designer judgements and contextual variables influence both the processes and resulting products in unexpected ways (Stolterman, 2009). It is important that design teams understand and plan for these variations so as to both capitalize on positive influences as well as control for negative ones, thus ultimately assuring that the best possible designs will emerge.

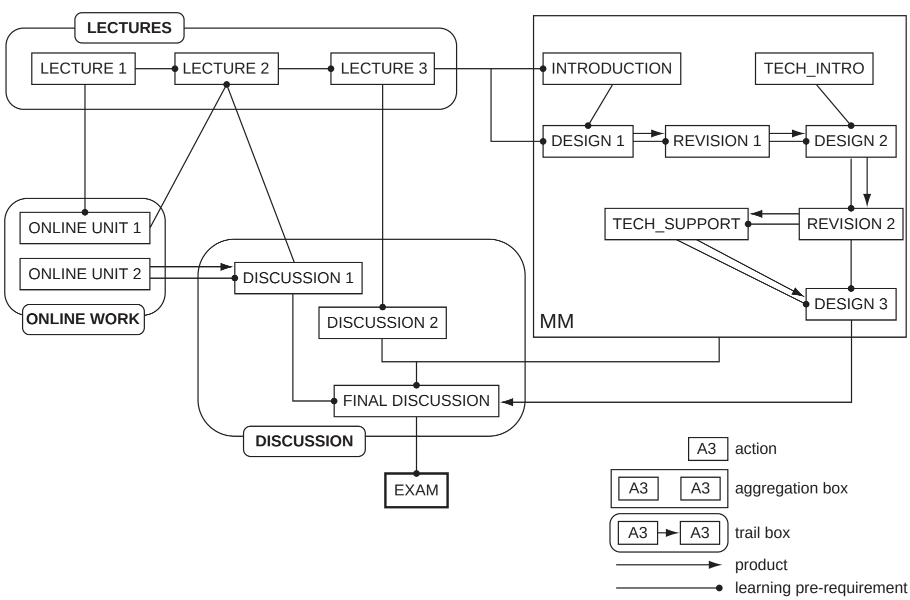

Figure 1.1 Example of dependencies diagram (Botturi, 2006).

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2

PRINCIPLES FOR DESIGN AND EVALUATION OF LEARNING SPACES

Mike Keppell and Matthew Riddle

INTRODUCTION

Interest in the influence of learning spaces on learning and teaching has been growing in recent times (e.g. Boys, 2011; Ellsworth, 2005; Goodyear, 2008; Luckin, 2010). Projects such as the Spaces for Knowledge Generation Project (Souter, Riddle, Sellers, & Keppell, 2011) explicitly focused on the influence of technology, economic and social developments in relation to learning spaces and how space influences both the role of the teacher and the learner and the range of learning approaches that can be undertaken within the space.

> The SKG project found that students move in nomadic but purposeful ways across a learning landscape of which the university is only part. Students are already enmeshed in a work/home/study continuum, and the problem for the university is to indeed advance these open and flexible communities on campus.
>
> (Souter et al. 2011, p. 1)

We define learning spaces as:

- physical, blended or virtual learning environments that enhance as opposed to constrain learning;
- physical, blended or virtual 'areas' that motivate a user to participate for learning benefits;
- spaces where both teachers and students optimize the perceived and actual affordances of the space; and
- spaces that promote authentic learning interactions.

(Keppell & Riddle, 2011, p. 5)

Formal physical learning spaces within higher education often have a preconceived function determined by traditional conceptions of teaching and learning that position the teacher as authority and the student as a relatively passive participant in the learning process. In order to provide a motivating and rich learning environment, formal physical learning spaces need to be adaptable and flexible for learning and teaching as opposed to being designed for one purpose. These spaces also need to emphasize authentic learning interactions. Informal physical learning spaces include learning commons that encourage both independent and peer learning. They allow students to repurpose the informal space to suit their own learning needs. Chairs, tables, access to Wi-Fi and power points need to be carefully considered to allow this individual customization (Keppell & Riddle, 2011).

Within this chapter we argue that design and evaluation are iterative and integral aspects of the design process, and that designers of learning spaces need to be involved in both aspects of the process to fully contribute to the design of learning spaces for contemporary learning and teaching. This chapter examines two cases that utilize seven principles of learning space design that support a constructivist approach to learning and support a learning environment that is student-centered, collaborative, active and experiential. These principles comprise: comfort, aesthetics, flow, equity, blending, affordances and repurposing (Souter et al., 2011). The first case utilizes the principles to inform the design of a space and the second case uses the principles to informally evaluate an existing learning space.

DESIGN PRINCIPLES FOR LEARNING SPACE DESIGN

The use of design principles to guide learning space design is quite common in the literature and such principles have been successfully utilized to design 21st-century learning spaces (Boys, 2011; Jamieson, Fisher, Gilding, & Taylor, 2000; JISC, 2006; Mitchell, White, & Pospisil, 2010). Previous research considering appropriate learning space designs for contemporary higher learning has identified the need for more attention to this area in suggesting that

> we need a better understanding of the role of space in the dynamics of creating more productive higher education communities (potentially involving considerations of institutional academic and managerial organisation and their part in social capital formation, as well as space design and maintenance issues), and its connections with learning and research. This should be the subject of further research.
>
> (Temple, 2007, p. 6; see also Temple, 2008)

Jamieson et al. (2000) suggested seven learning space design principles:

1. Design space for multiple uses concurrently and consecutively
2. Design to maximize the inherent flexibility within each space
3. Design to make use of the vertical dimension of facilities
4. Design to integrate previously discrete campus functions
5. Design features and functions to maximize teacher and student control
6. Design to maximize alignment of different curricular activities
7. Design to maximize student access to and use/ownership of the learning environment.

By considering the alignment of curricular activities with spaces there is an intention to integrate discipline pedagogies into the discussion. This is an inherent strength of these design principles.

JISC (2006, p. 3) suggested six principles for learning space design:

1. Flexible—to accommodate both current and evolving pedagogies
2. Future-proofed—to enable space to be re-allocated and reconfigured
3. Bold—to look beyond tried and tested technologies and pedagogies
4. Creative—to energize and inspire learners and tutors
5. Supportive—to develop the potential of all learners
6. Enterprising—to make each space capable of supporting different purposes.

A major strength of the JISC principles is the notion of 'being bold' and designing space that incorporates new technologies and new pedagogies. While physical spaces may endure for many years, technology needs to be updated on a more regular timescale than the actual physical space.

Mitchell et al. (2010) focused on the development of principles to guide the *redevelopment* of existing spaces in a project titled 'Retrofitting University Learning Spaces'. They developed eight principles and further categorized these principles under the headings of engagement, empowerment, ease-of-use and confidence. The eight principles are outlined below.

Engagement Principles

1. Spaces should support a range of learners and learning activities.
2. Spaces should provide a quality experience for users.

Empowerment Principles

3. Spaces should help foster a sense of emotional and cultural safety.
4. Spaces should enable easy access by everyone.

Ease-of-Use Principles

5. Spaces should emphasize simplicity of design.
6. Spaces should integrate seamlessly with other physical and virtual spaces.

Confidence Principles

7. Space should be fit-for-purpose, now and into the future.
8. Spaces should embed a range of appropriate, reliable and effective technologies.

A distinctive strength of these design principles is the emphasis on 'fostering emotional and cultural safety'. Mitchell et al. (2010) suggest an inclusive approach that focuses on multi-cultural awareness in the design of spaces. This is also a distinguishing characteristic in their learning space design principles.

The SKG project (Souter et al., 2011) posed questions about the design of learning spaces to suit the needs of learners as they generate knowledge. Acknowledging Barnett's (2000, p. 43) proposition that the pace at which knowledge is expanding makes the world 'radically unknowable', SKG focused on informal spaces and collaborative spaces. This shifts attention away from the design of traditional university learning spaces such as lecture theatres, and towards what Savin-Baden (2008) terms *dialogic spaces*, emphasizing a transformation through the contestability of knowledge and the exchange of ideas involved in academic work (p. 51), and *troublesome spaces*, where disjunction occurs (p. 95).

Souter et al. (2011) suggested seven principles of learning space design which support a constructivist approach to learning and support a learning environment that is student-centered, collaborative and experiential. The development of these principles explicitly embraced the student voice and we believe that this is a neglected area. Next generation learning spaces need to co-partner with students who are major stakeholders in the design and evaluation of learning spaces which they will occupy for a major part of their education. In fact, if occupation of a space determined the influence of the stakeholder then students would be the predominant stakeholders in the design process. The SKG design principles include:

1. *Comfort*: a space which creates a physical and mental sense of ease and well-being.
2. *Aesthetics*: pleasure which includes the recognition of symmetry, harmony, simplicity and fitness for purpose.
3. *Flow*: the state of mind felt by the learner when totally involved in the learning experience.
4. *Equity*: consideration of the needs arising from cultural and physical differences.
5. *Blending*: a mixture of technological and face-to-face pedagogical resources.
6. *Affordances*: the 'action possibilities' the learning environment provides the users, including such things as kitchens, natural light, Wi-Fi, private spaces, writing surfaces, sofas, and so on.
7. *Repurposing*: the potential for multiple usage of a space.

The SKG project was based on the philosophy that constructivist approaches to learning, as well as to research and study, should make use of technologies and approaches that students favour, and that learning spaces should therefore be organized to accommodate learner-generated aspects of learning. SKG provides a model for designing student learning environments that is future-focused and sustainable for the medium term (Souter et al., 2011). A legacy of this sustainable project has been the ability of the design team to apply these principles to the design of new spaces or to redesign existing spaces using the seven principles outlined above. The following case at La Trobe University provides an example of how the principles were utilized to repurpose an existing learning space. The second case at Charles Sturt University will outline how the principles were utilized for informally evaluating an existing learning space.

CASE STUDY 1: THE DESIGN OF A TECHNOLOGY-ENRICHED LEARNING SPACE

The Exemplar Learning Facilities Project

In July 2011 at La Trobe University, a project steering committee was formed to undertake a programme of upgrades to existing teaching spaces. The project, named 'Exemplar Learning Facilities' (ELF), was established after a comprehensive audit of the utilization rates and configuration of the university's teaching and learning spaces, which found, among other things that: 'there is currently an inadequate spatial provision per seat/ student which inhibits the adoption of alternative teaching and learning modes particularly at the Melbourne campus' and 'the existing furniture style (typically tablet chairs, long narrow tables or small 500 × 500 tables) is inappropriate for a tertiary institution which seeks to promote team and peer to peer learning' (La Trobe University, 2011, p. 1).

The audit report refers to La Trobe's curriculum renewal process under the banner of *Design for Learning* (La Trobe University, 2009) in stating that the guidelines were established in order to: 'complement other University initiatives to improve learning outcomes and a *Design for Learning* aim that graduates acquire a capability to work in teams and understand the dynamics of teamwork' and 'inform and direct design decision-making in both new and adaptive reuse learning space projects' (La Trobe University, 2011, p. 2).

These design guidelines were produced by a working party of La Trobe's Learning Spaces and Technologies Committee. Considering a suite of teaching spaces, the guidelines outline principles including the design of adaptable and flexible flat-floored teaching spaces with adequate special standards to support collaborative, peer-to-peer learning.

The ELF project scope included six rooms across campus, with priority placed on the development of two new, experimental learning spaces in the Social Sciences Building in order to prototype these ideas. It proposed the establishment of 'highly adaptive and interactive (technology-enriched) collaborative cross-discipline spaces fitted out with loose tables' (ELF Project Steering Committee, Terms of Reference). The establishment of state of the art facilities would require reducing the capacity of two existing seminar rooms from 108 to approximately 60 students in each, according to the spatial standards proposed in the new guidelines.

Project Approach

The project steering committee decided that the best way to go about the project was using two different prototypes. One of the prototypes would trial a more conservative design response, while the other would push the current technological boundaries to develop a collaborative learning space design with a sharper future focus.

ELF Learning Space Design Principles

Development of these experimental spaces, known in the project as Prototype A and Prototype B, involved a careful consideration of the primary point of focus of the room. In the traditional configuration used prior to the project and shown in Figure 2.1, fixed rows of chairs faced towards a fixed lectern, lengthways in the room. A single projector focused on the wall behind the lectern. Under the ELF project, these rooms were designed to have less of a focus on a single delivery point, allowing for team teaching and group work to be supported and suggested. This aspect of the design was seen as particularly important to the ability of the room to be flexible in supporting didactic teaching as well as enquiry-based and problem-based learning. This follows from the SKG principle of *repurposing*, and is important to the overall success of the design.

Comfort and *aesthetics* are two principles that were absolutely central to the ELF project. The existing configuration of the space was uncomfortable for students in a number of important ways. Due to the use of fixed tablet chairs in rows without any

Figure 2.1 This photo, taken prior to the ELF project, shows the orientation of fixed furnishings towards a lectern used in both the spaces redesigned with Prototype A and B.

room for a central aisle, students were not able to move freely in the room, and those at the back were forced to look at the projector display with an uncomfortably small viewing angle. Hearing clearly in these rooms could also be challenging, and lecturers complained about strained voices at the end of long days. Visual comfort was addressed in the redesigned spaces through the provision of dual projection on the long wall (Figures 2.2 and 2.3) and acoustic comfort was improved with the use of acoustic dampening on ceiling beams. Aesthetically, the rooms were quite plain, and their design suggested a pedagogy that no longer matched with the desire for redesigned pedagogies under *Design for Learning* (La Trobe University, 2009) that involve active learning and team work. As Figures 2.1, 2.2 and 2.3 show, the redesigned spaces are considerably more attractive and make use of engaging colours and shapes.

Figure 2.2 Prototype A after completion. Floor markings in the carpet tiles indicate the home position of tables. The lectern has been moved to the long wall and dual projection is in place.

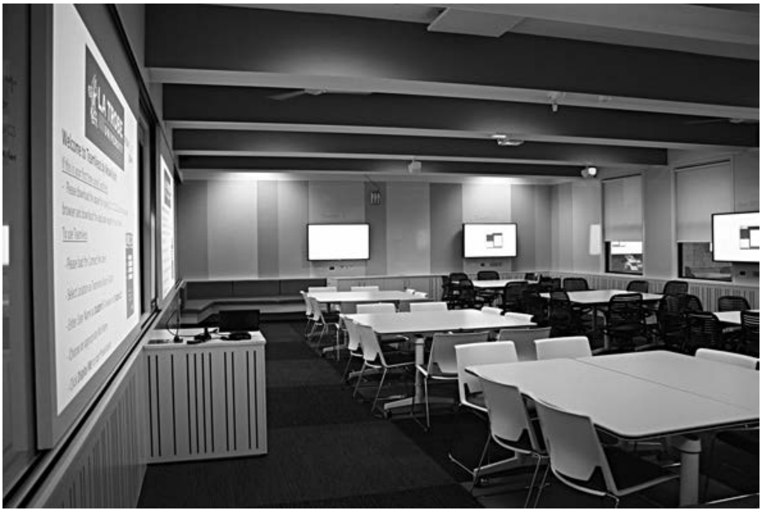

Figure 2.3 Prototype B after completion. This room employs a subtle lectern design, tables in pairs and six team pods with wireless video capability.

The principle of *flow* was also at work in the development of the design. Csikszentmihalyi (1990, p. 4) describes *flow* as 'the state in which people are so involved in an activity that nothing else seems to matter'. The SKG design principles adapt this concept to inform the design of learning spaces, suggesting that spaces should be configured to enhance rather than interrupt the process of finding *flow* in the generation of knowledge. In particular, teaching staff involved in the ELF design team were concerned that the reconfiguration of furniture in the rooms should not distract or divert the flow of learning during class time. These academics also advocated for adequate provision for breakout discussion spaces to promote creative thinking, with discussion groups ranging from three to eight students.

The ELF spaces are designed to support students in subjects making use of collaborative learning approaches such as Enquiry-Based Learning (EBL) and Problem-Based Learning (PBL). EBL is 'a broad umbrella term to describe approaches to learning that are driven by a process of enquiry' (Kahn & O'Rourke, 2005, p. 1). The purpose of using EBL and PBL approaches is to promote active learning and to constructively align the outcomes, teaching and learning and assessment of courses (Biggs, 2012). In this way, the ELF spaces have been designed with *pedagogically informed* principles as recommended by Jamieson et al. (2000). To achieve this, two lecturers coordinating courses that involve EBL and collaborative project work were co-opted to the project steering committee. These academics made it clear that the need for students to work in groups of three or four was particularly important to the learning design of their courses. This was a crucial turning point for the design of the furniture layout in the ELF rooms. Two different default layouts are offered by the prototypes chosen by the project shown in Figures 2.2 and 2.3, with each allowing alternative layouts with separate tables to support small groups.

The ELF spaces have been designed to support active learning, creating what Savin-Baden (2008, p. 104) calls *troublesome* learning spaces, because learners are placed in a mode of enquiry that causes a disjunction—a key catalyst to engage learners prior to transformation of knowledge. Those involved in the ELF project were keenly aware that the pedagogical design and the learning design go together to create these circumstances for learning.

Both prototype designs make use of hardwearing flip-top tables on casters that can be quickly and easily repositioned, or folded away altogether. Each room includes both chairs with casters and on sleds in order to fully test both approaches. In each case the chairs were chosen to be durable, light and easy to move.

Floor markings in the carpet design show the ‘home position’ of moveable furniture. In the case of Prototype A (Figure 2.2) this arranges ten tables of six students each individually in two gentle arcs, with three additional breakout spaces created by banquette seating. In Prototype B (Figure 2.3) 14 tables are arranged in pairs, accommodating eight students at each of seven large tables in the ‘home position’. These can be drawn apart towards the wall for smaller group discussions, and the room includes two breakout spaces with banquette seating.

The ELF project has a particular focus on the SKG principles of the *affordances* of learning space technologies, as well as the *blending* of face-to-face learning with students’ own digital devices. The most striking addition in Prototype B is the inclusion of six extra digital monitors fitted with wireless video presentation capabilities as well as input panels supporting physical input of video from laptops and other devices. The wireless video capability is an affordance of this space that represents a new approach for La Trobe, and allows videos and presentations to be sent directly to any of the monitors without plugging in any cables.

Each room also includes a state of the art document camera, as well as the tried and tested low-tech group work technologies of huddle-boards, fixed whiteboards and pinboards. Huddle-boards are small, lightweight whiteboards that can be used by groups at a table and then hung on a rail or placed underneath a document camera for presentation to a larger group. These technologies are particularly useful in supporting learning designs that require students to make presentations, work in groups and demonstrate active listening skills.

CASE STUDY 2: EVALUATING THE THURGOONA LEARNING COMMONS

The Thurgoona Learning Commons (TLC) is located on the Albury-Wodonga Campus at Charles Sturt University. The TLC houses the library collections, learning skills advisors and Indigenous Student Services. More recently, other campus services have migrated to the Learning Commons as it has become a hub for student engagement and has become the *agora* or community centre of the campus. (The agora was a gathering place or assembly point in ancient Greek city-states and represented a lively market place of the city.)

The TLC has been designed and built to conform to the environmentally friendly ethos of the campus, which has a strong emphasis on sustainability.

> The Albury-Wodonga campus was designed to function autonomously, drawing minimally on external services, using material resources sparingly and generating significantly less waste. The comprehensive, environmentally sensitive design process

> that encompassed all stages from site planning to the selection of materials, succeeded in creating a campus based on far more rigorous principles of sustainability than any project of comparable size in Australia.
>
> (Rafferty, 2012, p. 53)

The TLC has natural ventilation and natural lighting to align with the principles of this environmentally friendly campus. The TLC has a diverse range of spaces that were designed to enhance independent and peer learning (Oakley, 2008).

The seven principles of learning space design were utilized to informally evaluate this 21st-century space in order to test the framework in relation to evaluation of learning spaces. In terms of *comfort* the TLC space creates a physical and mental sense of ease and well-being through the use of natural lighting including high ceilings and visual connection to the outside quadrangle through large glass windows at the front of the building. This area in the front of the building is also the 24-hour access area where students can congregate and socialize with other students. It is a place for students to meet and discuss their work on an informal basis. It also introduces students to the milieu of studying at the Thurgoona campus.

As can be seen from the photo in Figure 2.4, the *aesthetics* of the learning space demonstrate principles of symmetry, harmony, simplicity and fitness for purpose. The space is designed to be welcoming and allow students to undertake peer-related discussions. It is also the area where students enjoy congregating. As staff or students enter the learning space there is an appreciation of thoughtful and considered design.

Figure 2.4 The Thurgoona Learning Commons 24-hour access area.

> The aesthetic appeal of a learning space, then, will not just be the utilitarian fact that it has a particular level of technology or affordances, but the way the technology or affordances fit into the whole. It may also include the non-utilitarian enjoyment of the design of the space, the outlook, the furnishings, colours, light, view.
>
> (SKG Website, 2011)

In addition it is hoped that the space would facilitate students to engage with their learning and experience *flow* (Csikszentmihalyi, 1990).

The TLC also aligns with the principle of *equity* as it considers cultural and physical differences. It has an inclusive approach to students and teachers who utilize the space. The entrance and entire learning space have been designed so that they are accessible to students and staff with disabilities. The inclusion of the Indigenous Student Services sends a positive message to all staff and students working in the area. In addition the range of spaces—from noisy, social learning spaces, group study areas, to quiet

Figure 2.5 Range of group and independent spaces throughout the Thurgoona Learning Commons.

individual areas—allow the students to decide how they wish to study within the space. A student can transition through each of the spaces depending on the task on which they wish to focus.

In addition, the *timescape* of the semester will influence the mix of peer and independent study that is required. Timescape refers to the different use of the same learning space over a semester. For example, early in the semester a student might wish to discuss an assignment topic with a group of students in the learning space. When students are getting closer to exams they might wish to gravitate to a quiet, individual space toward the back of the TLC to prepare for the impending exam. The lower ceilings toward the back of the TLC also assist in minimizing noise and creating a sense of privacy.

The TLC has explicitly accounted for a mixture of technological and face-to-face pedagogical resources through a *blended* approach. 'Blended and flexible learning' is a design approach that examines the relationships between flexible learning *opportunities*, in order to optimize student engagement (Keppell, 2010). The blended learning environment is a necessity for teaching and learning. The design of learning spaces needs to embrace the nomadic student who needs wireless and other technology, seamless connection and uninterrupted usage irrespective of the type of technology being used (Taylor, 2012). Within the TLC, there is an explicit need to blend face-to-face pedagogical experiences with access to CSU Interact, the university's virtual learning space. There are both PC and Mac computers for students to access resources and applications that require the greater bandwidth provided by a fixed network. In addition, since students are coming to regard the use of laptops and mobile devices as the norm, wireless access is pervasive within the TLC. Residential students also appreciate the ability to easily access the wireless network within the 24-hour access area and the TLC is a major space for interactions on the campus.

There are multiple 'action possibilities' for this learning space. As suggested previously, there are noisy social spaces, group study rooms and individual study areas *affording* informal peer learning, structured peer learning and independent learning, respectively. An important aspect of affordances is that the student needs to appreciate both the perceived and actual affordances of the learning space. By recognizing the perceived possibilities of the space for learning the student will be more likely to utilize the space when needed. The variety of spaces promotes student learning and is enhanced by Wi-Fi, vending machines for snacks, and comfortable sofas that can be reconfigured by the students. Students can repurpose the spaces by moving chairs and tables into group settings or *repurposing* the space to suit their needs for group discussion, group projects or independent study.

CONCLUSION

The two cases discussed suggest that the SKG seven principles of learning space design have potential in assisting the design of learning space and in the evaluation of learning space. In undertaking both the design and evaluation of the spaces at two universities the authors have elaborated the design principles to include questions that may further guide design and evaluation for multiple stakeholders. These are summarized in Table 2.1.

The SKG design principles focus on questions to ask both staff and students working in an informal learning space.

Table 2.1 SKG Design Principles and Focus Questions

Principle	Questions
Comfort: a space that creates a physical and mental sense of ease and well-being.	How comfortable do you feel in this learning space? Do aspects of the learning space distract you from learning? What area in the learning space do you spend most of your time in and why? Is there an area where you don't feel comfortable in the learning space?
Aesthetics: pleasure, which includes the recognition of symmetry, harmony, simplicity and fitness for purpose.	What features of the learning space do you appreciate? Is the space fit for purpose in relation to learning?
Flow: the state of mind felt by the learner when totally involved in the learning experience.	Do you feel you can engage with your work in the learning space? Are there areas in the learning space where you can focus on your individual work?
Equity: consideration of the needs of cultural and physical differences.	Do you think the learning space is inclusive of all people? What features of the space promote an inclusive approach?
Blending: a mixture of technological and face-to-face pedagogical resources.	Do you utilize your own mobile device in the learning space? How easy is it for you to connect to the network? How often do you rely on the technology within the space?
Affordances: the 'action possibilities' the learning environment provides the users, including such things as kitchens, natural light, Wi-Fi, private spaces, writing surfaces, sofas, and so on.	What does this learning space allow you to do that you cannot complete in another space? Do you learn from other users about how to use the space? Are there parts of the learning space that you avoid because you don't know how to use them?
Repurposing: the potential for multiple usage of a space.	Do you move tables and chairs to create your own learning area? What parts of the learning space do you reconfigure to suit your learning style? Are there areas in the learning space that you constantly reuse for this reason?

Future design and evaluation of our spaces will utilize these questions to enable further insight into the use of learning spaces by both staff and students. By focusing on the key stakeholder perspectives we should be able to provide insightful feedback on the usefulness of the SKG principles for both design and evaluation of learning spaces in higher education.

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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 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.

> 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

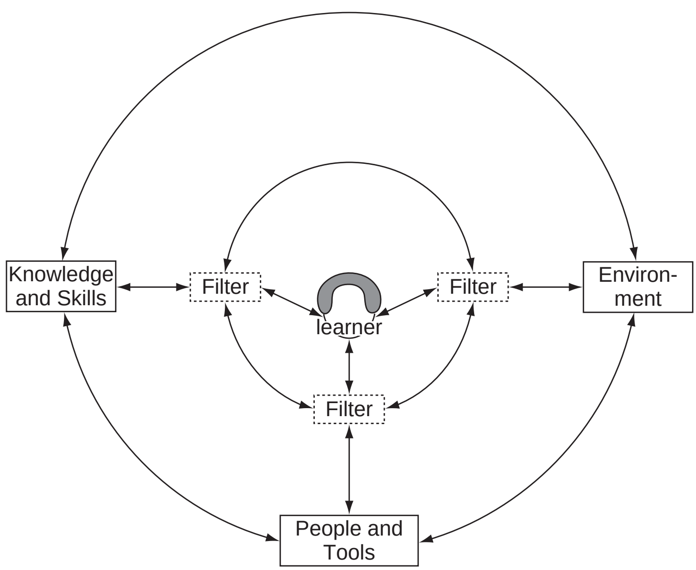

Figure 3.1 The Ecology of Resources Model (Luckin, 2010).

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.

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 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).

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

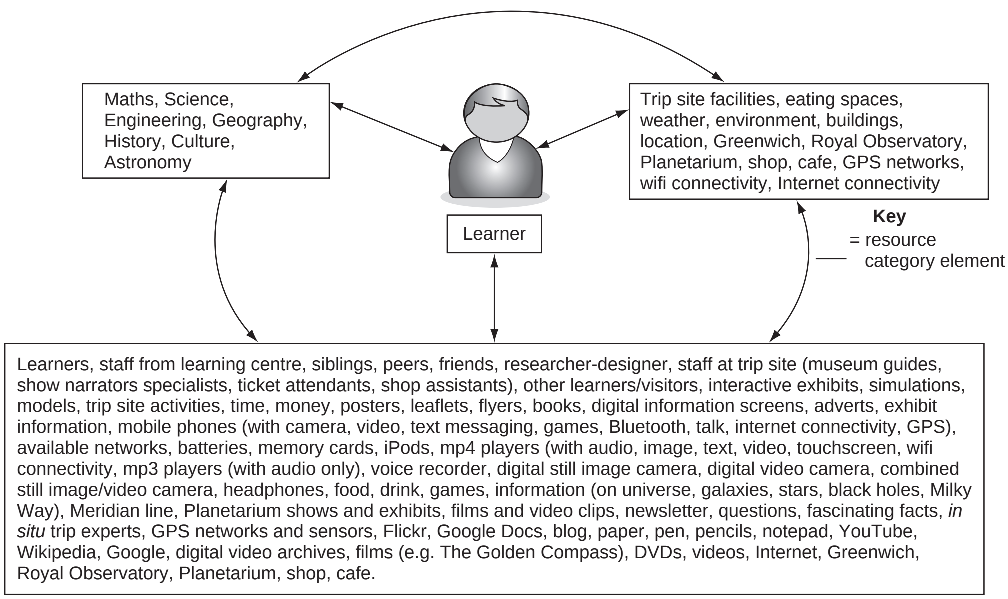

Figure 3.2 An Ecology of Resources model after an initial design iteration.

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)