TECHNOLOGY ENHANCED LEARNING

Technology-Enhanced Learning

Design Patterns and Pattern Languages

Peter Goodyear and Symeon Retalis (Eds.)

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Technology-Enhanced Learning

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Scope

The rapid co-evolution of technology and learning is offering new ways to represent knowledge, new educational practices, and new global communities of learners. Yet the contribution of these changes to formal education is largely unexplored, along with possibilities for deepening our understanding of what and how to learn. Similarly, the convergence of personal technologies offers new opportunities for informal, conversational and situated learning. But this is widening the gulf between everyday learning and formal education, which is struggling to adapt pedagogies and curricula that were established in a pre-digital age.

This series, *Technology-Enhanced Learning*, will explore learning futures that incorporate digital technologies in innovative and transformative ways. It will elaborate issues including the design of learning experiences that connect formal and informal contexts; the evolution of learning and technology; new social and cultural contexts for learning with technology; novel questions of design, computational expression, collaboration and intelligence; social exclusion and inclusion in an age of personal and mobile technology; and attempts to broaden practical and theoretical perspectives on cognition, community and epistemology.

The series will be of interest to researchers and students in education and computing, to educational policy makers, and to the general public with an interest in the future of learning with technology.

Technology-Enhanced Learning

Design Patterns and Pattern Languages

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PREFACE

This book is concerned with improving the quality and outcomes of learning, in all those varied circumstances where technology plays a significant supportive role. We use the umbrella term 'technology-enhanced learning' or TEL to denote this field. Designing usable, effective interactive TEL environments in an efficient affordable way is a demanding task, which requires creativity and a significant amount of expertise. Designing for effective learning is a complex problem involving the design of learning tasks, learning resources and divisions of labour that enable each learner to learn effectively.

Practitioners (teachers and TEL designers, particularly novice ones) need tools and methods to help them produce effective designs. Practitioners want guidance that is based on sound research and tested experience about what will support effective learning; but advice that is too prescriptive, or based on a single model, doesn't help them to create innovative designs, suited to their particular context, that make the most of new and evolving technology.

This book presents research and development work on the use of *design patterns* as aids to TEL design. In principle, design patterns can help designers in bridging between theory, empirical evidence and experiences (on the one hand) and the practical problems of design (on the other). Design patterns are abstractions based on empirical observation of recurring phenomena in the environment, but they are also normative: the text of pattern descriptions is meant to help one act in a certain way.

This book is the first thorough exploration of the use of design patterns for building effective and usable TEL environments. Design patterns, we believe, can play an important role in helping technologists, teachers, educational designers and subject-matter experts develop and share the much richer language and concepts required for learning in the 21st Century. They can facilitate communication within interdisciplinary and multi-perspective teams.

The contributions to this book have all been influenced, directly or indirectly, by the work of an extraordinary man: the mathematician and architect, Christopher Alexander. Alexander's thinking about built and natural form is captured in a number of books, starting with *Notes on the synthesis of form* (Harvard University Press, 1964) and most recently expressed in the four volumes of *The nature of order* (Center for Environmental Structure, Berkeley, CA, 2006). As we explain in Chapter 1, Alexander's ideas have had a profound impact on design thinking and design practices in a number of areas outside architecture – notably in software engineering. Alexander has occasionally commented on the adoption and transformation of his ideas in these other fields of practice, but he does not concern himself directly with information technology, let alone its use in education.

Access to information can be an aid to learning, but learning with the aid of technology involves much more. It would be fair to say that our scientific understanding of how people learn with the aid of technology, and our suggestions for helping them improve their learning, have struggled to keep up with technological change. True, researchers have studied each new wave of technological innovation, trying to see what is different and potentially of educational value about each new product or service. In addition, our broader conceptions of learning have shifted and strengthened. But there is still a sense of a field running to keep up, and repeatedly stumbling. Some commentators wonder whether it will ever again be possible to distil any worthwhile guidance for learners and teachers, given the accelerating pace of change and the shortening half-life of research findings. This sense of speed, fluidity and uncertainty is in stark contrast to some of Alexander's core concerns. For example, among the trilogy of books that has had most direct influence on ICT practitioners is a delightful volume called *The timeless way of building* (Oxford University Press, 1979). Some of those who criticise the idea of using Alexander's design principles in areas like educational technology do so on the assumption that fast-moving fields never accumulate the experience of success that underpins distillations of 'best practice'.

We take a contrary view. We have become convinced, during many years of working with technology in education, that research and the provision of useful guidance depend upon being able to see enduring forms in novel technological configurations: to see what is old in the new, as well as what is revolutionary. Successful work also depends upon a strong sense of value. Alexander talked of 'the quality without a name', a subtle combination of characteristics that help make somewhere feel a good place to be. We have become convinced that it *is* possible to discern deeper recurring qualities in learning experiences that people enjoy – the trick is to look below the surface, and see how technology can be used to help nurture what people value.

Peter Goodyear & Symeon Retalis, Sydney & Athens, February 2010.

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PETER GOODYEAR AND SYMEON RETALIS

1. LEARNING, TECHNOLOGY AND DESIGN

INTRODUCTION

This chapter provides an orientation to the key themes of the book, as well as an overview of the individual contributions. We introduce and develop a number of ideas that underpin the coherence of the collection. Learning is, of course, at the centre of our concerns – supporting other people's learning is the point of our enterprise. But we approach this indirectly. The book itself is about how people who are professionally engaged in supporting other people's learning can share their experiences. To bring extra focus to the book, we are specially concerned with situations in which technology is also being used to help people learn. The umbrella term we are using for this is 'technology-enhanced learning' or TEL, but other terms, such as computer-assisted instruction (CAI), computer-aided learning (CAL), networked/online learning and e-learning carry similar connotations. Using technology to help other people learn is complex. It needs to be approached in a planful spirit. That is why we speak of design. Indeed, the essence of the book is about how to help people share TEL design ideas and experiences. It is a book for people engaged in the practical work of TEL design, but also for those who want to help such people collectively improve what they do. This may seem a rarefied position – at several removes from the student experience – but this also gives the work a multiplier effect. Its benefits are amplified by the activities of those who help teachers and other educational designers do a better job for the many learners they, in turn, support.

We will spend some time introducing a number of ideas. Some of these, like learning, can seem quite familiar. But they need careful handling, because of the slipperiness of everyday usage. We also have some less obvious themes to develop, such as the need to be able to see deep continuities beneath the surface of change. TEL may look as if it is born anew every few years – such that some people claim there is no possibility of accumulating relevant design experience – whereas the practiced eye can see beneath the wrappings.

LEARNING AND DEEP CHANGE

In turbulent times success, and sometimes survival, depend upon the ability to distinguish between what is changing and what is staying the same. Adaptation is not enough. Indeed, adaptation in response to the surface features of change – attending to symptoms rather than causes – can be fatal. Human beings have

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demonstrated an extraordinary capacity to survive and succeed by adapting to changing circumstances, abandoning established practices while also avoiding new perils and taking advantage of new opportunities.

Learning and adaptation are closely linked. Some of the oldest, most deeply-rooted and most powerful methods of human learning – through observation, imitation and participation – work best when what must be learned is directly available to the senses. A child's learning of its native language(s) and the pre-linguistic sharing of tool-making skills are good examples (Hutto, 2008.) But what happens when survival depends upon understanding *deep* change rather than merely adapting to that which is readily apparent to the senses? Roughly speaking, humankind now has two strategies. One is based on language, abstract thought and the ability to deal with complex conceptual systems. It involves the creation and manipulation of symbolic representations of the world: it underpins much of science. The other uses information and communication technologies (ICT) to render visible – more broadly, to make available to the senses – that which would otherwise be abstract or hidden. Of course, these two strategies are often combined, as when scientists use visualisation techniques to understand the structure of complex molecules or the cosmos. In formal education – by which we mean much of what happens in schools, colleges and universities – there has, for a century or so, been a strong emphasis on abstract thought and complex symbol systems. This has produced a small cadre of competent scientists but has signally failed to equip the majority of us to help make decisions on issues of national and global importance. In short, most people find the acquisition of complex conceptual knowledge hard. We find ourselves trying to reason about and discuss macroeconomics or climate change using domestic analogies and anecdotal evidence. Much of the public discourse of politicians, journalists and pundits is stuck in the same mire. One of the great challenges for those who work in educational technology and the learning sciences is to create tools and resources – or powerful learning environments – that help everyone use their innate learning abilities to come to understand things which are not otherwise directly available to the senses.

Learning is often hard, but it's never been more important. It is key to prosperity for individual people, for the firms or other organisations in which they work, for the competitiveness of national economies, and – it would now seem – for global stability and survival. Technology, especially ICT, has been part of the complicated network of processes involved in the globalisation of work, ideas, capital and risk (Lash & Urry, 1994; Urry, 2003; Castells, 1996; 2006). It has allowed banks to spread toxic debt just as it also allows monitoring of carbon emissions and modelling of climate change. It *can* play a role in helping people, as individuals or in community groups, companies or governments, take knowledgeable action. It can do this in a variety of ways. The last few years have seen enthusiastic take-up of so-called Web 2.0 technologies – including social networking technologies that can empower community action groups and strengthen political parties. We have already alluded to ways in which visualisation technologies can render abstract ideas concrete and manipulable. There have also been trends to embed ICT in domestic and working environments – captured in ideas like ‘ubiquitous computing’, ‘ambient intelligence’, ‘wearable computers’ and even ‘the disappearing computer’ (Bell & Dourish, 2007). ICT is finding niches in formal education: not just laptops for students but interactive whiteboards, digital libraries, e-portfolios, learning management systems, simulations, videoconferencing, virtual laboratories, programmable and location-aware devices. As Seymour Papert cautioned, 30 years ago, it is tempting but dangerous to imagine that our recent experiences of ICT are a reliable guide to what ICT will be like in the future – even the near future (Papert, 1980). The pace of ICT innovation is not slackening and we are witnessing an accelerating interpenetration of the digital and material worlds: such that it will become hard to see where one stops and the other begins (Mitchell, 1995).

This has profound implications for the work of anyone who is professionally involved in helping other people learn. Bluntly put, it would be a profound mistake to imagine the skillset they will require by projecting current manifestations of educational technology more than a few years into the future. We need a more radical and holistic imagination. We also need to distinguish between enduring fundamentals of learning and teaching and the transient froth splashed up by each new wave of innovation.

Learning – as we will see in a moment – can be implicit, informal and formal. Technology can enhance all three kinds of learning, as well as their combination. Technology can be used to tighten *or* slacken the bonds between perceiving, learning, knowing and action. It can provide scaffolding for our unsteady attempts at tackling new problems. It can be designed into artefacts to shape our behaviours in ways that we only subsequently come to understand and endorse, or reject. Once one acknowledges the rich and growing set of possibilities for connecting technology, minds and action, old definitions of the scope of ‘educational technology’ and ‘instructional design’ look peculiar and quaint.

This brings us to one of the major problems that have to be tackled by anyone producing a book about TEL design. It must be future-oriented without being futuristic. It must be underpinned by a conception of the scope and practices of design that will not seem dated within a couple of years. It cannot be obsessed by the tools and assumptions of the moment. It needs to be informed by a sense of the trajectory and pace of change, but not be captured by wishful thinking or technological romanticism. In bringing this collection together, as well as in collaborating in some of the research reported in the book, we are making a clear commitment to a set of ideas about TEL design. We go into these in more detail below, but included among them are beliefs that: education needs to become more design-savvy if it is to improve outcomes for the majority of learners; TEL design is a job for teams of people, rather than for lone individuals; TEL design is hard, takes time and needs experience, but TEL design experience *can* be shared. This book arises from a conviction that design patterns and pattern languages are worth serious exploration as candidates for sharing TEL design experience. To convince you of that, we will need to say something about what the patterns-based approach entails.

THE PATTERNS APPROACH TO SHARING DESIGN EXPERIENCE

At their simplest, design patterns encode design experience by pairing a *problem* statement and a *solution*. The problem:solution pairing is almost always set within some larger *context*, and the solution is expressed in a way that leaves details to be worked out, or *embellished* by other, lower-level patterns. Most important, the text of the pattern also includes a *rationale* (drawing on research, theory, experience, etc). Patterns can be connected in sequences, known as pattern languages. We realise this description is rather abstract and will provide some concrete examples shortly.

Notions of sharing and re-using TEL designs have been around for some time (see e.g. Pirolli, 1991; Goodyear, 1994; Koper & Tattersall, 2005). The goals and assumptions of the work in this area have been quite varied. *Our* commitment to the task of developing and testing patterns and pattern languages for TEL depends on a distinctive combination of goals and assumptions. In particular, we see the patterns-based approach as offering a way of capturing design experience that:

1. Connects recognisable problems with tested solutions
2. Relates to design problems at any scale level (micro, meso, macro, etc), and connects design solutions across scale levels
3. Can be supplemented with research-based evidence
4. Balances guidance with creativity
5. Has wide application but is customisable to meet specific needs
6. Can improve design performance while also educating the designer.

An advantage of using TEL design patterns, especially when combined into pattern languages, is that they have the flexibility to cover the broad and expanding space of TEL design challenges we sketched above. This is because the same *kind* of pattern can be used to represent design experience that refers to quite heterogeneous design components – learning tasks, digital resources, material spaces, composition of learning groups, etc – and that refers to the integration of design components at various scale levels (e.g. to improve the alignment between the requirements of a learning activity and the affordances of the nested physical and digital spaces in which it is set). These claims will be easier for us to explain, and for you to assess, when we have said more about the nature of design patterns and pattern languages (below).

Another element we need to introduce into the mix is the matter of values. It *is* possible to approach instructional/educational design as if it were a value-free zone – a space for the exercise of value-neutral technical expertise. We disagree with this notion. Value-neutrality is talked about, within the TEL field, in a number of ways. Some will argue that technology itself is neutral – it can be *used* in good and bad ways. Some will talk about the ‘pedagogical neutrality’ of technologies or designs – implying that such neutrality is virtuous, in that it extends an invitation to educators of all persuasions: creating an open church. We are not convinced, but don’t want to spend time here engaging in a futile argument about naïve conceptions of neutrality. Quite the opposite. Part of what attracts us to the world of design patterns is that many pattern-hatchers have a strong sense of the need to search for what is *good*. This goes back to the original work of Christopher

Alexander, whose concern for patterns in built space was rooted in a quest to understand what makes spaces *live*; what imbues them with the qualities that make us feel most alive and complete. This may seem an overblown conceit when applied to TEL. Again, we disagree – but the proof of the pudding is in the eating.

PURPOSE OF, AND AUDIENCE FOR, THIS BOOK

We have produced this book in the hope that it will be both a landmark and a signpost. It represents the maturing of a specialist field still occupied by only a few hundred people. The earliest work on pedagogical design patterns dates back to 1996 (Sharp et al., 2003). Take-up of this work in the TEL field began a year or so later (see Lyardet et al., 1998). A number of researchers around the world began independently exploring the possibilities of TEL design patterns and pattern languages: the fruits of some of this work is summarised in chapters of this book. In addition, a collaborative exploration of the area gathered momentum in the period 2002 to 2005, with the help of European Union funding for the ELEN and TELL projects, both of which were directed by Symeon Retalis and involved Peter Goodyear. Other chapters in the book have been written by people who collaborated in one or both of these projects. In this sense, the book is a milestone – it marks progress to a worthwhile viewpoint. But we hope that it will come to be seen as just the first major marker on what turns out to be a long journey, involving many more people – not just researchers but also design practitioners and those who educate and mentor designers, and who sponsor good design. Each chapter reviews work done, but also, implicitly or explicitly, suggests new roads to be travelled. We have chosen the chapters as much for what they suggest and inspire as for the accomplishments that they document. In addition, we have provided a closing chapter which also identifies some important open questions and recommends some promising lines for further R&D work.

It will be clear that our primary audience is the community of people who are seriously involved in TEL R&D. This is not just a book for academic researchers; it is also meant to be of value to people whose innovative spirit finds expression in creating new tools and systems. There are tensions and synergies in the work of research and development – rather like the tensions and synergies between experimental and theoretical physics. We hope that this book will help people advance on both fronts.

We have not assumed that teachers in formal education – whether at school or tertiary level – will provide a natural audience for the book. We hope that it *will* have a detectable effect on educational practice, but that effect is likely to be mediated by the R&D community and by those who write directly for, and teach, TEL designers.

We now turn to a concise but necessary discussion of some of the key elements we sketched above, in order to set the stage for the chapters which follow. We need to say a little more about: learning, technology-enhanced learning, design, the sharing and reuse of designs, design patterns and pattern languages, and the question of value.

LEARNING

Learning is conventionally defined as the process of acquiring competence and understanding. It results in a new ability to do something, and/or an understanding of something that was previously not understood. Competence is sometimes described in terms of possessing specific skills; understanding in terms of possessing specific knowledge. Some accounts also talk of attitudes: learnable predispositions to act in specific ways. From the 40s to the 70s, it was common to speak about learning by referring only to observable behaviours – such that learning was described as a process through which experience brought about lasting changes in behaviour. Since the 70s, it has become respectable to talk about inferred (rather than directly observable) mental structures and processes – for example, to talk about learning as a process which results in changes to long-term memory. Researchers in the learning sciences have assembled a substantial array of theoretical constructs with which to describe processes of learning and knowing, including taxonomies of types of knowledge (e.g. declarative, procedural, strategic, situational; implicit and explicit; general and domain-specific, etc). Within this scientific tradition, there is a strong consensus that different kinds of knowledge are acquired in different ways: e.g. facts are best learned through clear exposition, activation of prior knowledge and repeated exposure; skills are best learned by observation and then practice with feedback; complex declarative knowledge is best learned through participation in discourse, etc (see e.g. Ohlsson, 1995; Chi & Ohlsson, 2005).

A good deal of research and development work in the overlapping fields of educational technology and the learning sciences has been motivated by a belief that formal education is failing to meet the needs of individuals and society. Its failings can be seen in (i) the weaker performance of students from poorer families (i.e. education is reproducing inequalities) and (ii) the fact that much of what students learn turns out to be inert, fragmented knowledge. It is fit for recall and reproduction in time-limited exams, but it is not much use for solving problems outside the exam hall (Renkl et al., 1996).

In diagnosing and starting to act upon these weaknesses, recent research has:

1. Looked more closely at the character and constituent elements of real-world expertise, delineating the differences between novice and expert in many different domains of practice, and showing how experts see problems differently from novices, draw on a solid foundation of experiential knowledge, and are able to continually learn, deepen and broaden their knowledge base, improvise and experiment – their expertise is *adaptive* (Alexander, 2003; Ericsson et al., 2006). Unless we have a clear idea of what experts actually do, and how they do it, we cannot point novices in the right direction.
2. Examined learning and action from a *situative* perspective – moving beyond what a lone individual might be said to know, or be able to do, to consider activity systems (see e.g. Greeno, 2006). In Greeno's words, activity systems are "complex social organisations containing learners, teachers, curriculum materials, software tools and the physical environment" (op. cit., p79). In design terms, the situative view focuses attention on "characteristics of activity systems that can result in

learners increasing their capabilities for participation in ways that are valued" (op. cit., p80). Learning comes to be understood as both an individual cognitive accomplishment and the ability to engage effectively in a valued social practice, appropriating the symbolic and material tools of a culture (Saljo, 1999).

3. Taken seriously the idea of knowledge work and *learning to think for a living* (Davenport, 2005; Goodyear & Ellis, 2007). This has been pursued in a number of ways, but most significantly through giving students authentic opportunities to engage in 'knowledge building' – working with others on the improvement of ideas (Bereiter, 2002).

4. Combined ideas about activity systems and knowledge building to test and experiment with conceptions of learning in communities of inquiry; or locating learning as apprenticeship in a community of practice (Wenger, 1998).

5. Begun to recognise that learning is influenced by, and needs to be understood in terms of, phenomena that come to bear at a number of scale levels – from 'neurones to neighborhoods' (National Research Council, 2000). This includes a recognition that some learning processes – which can be labelled *implicit* learning – seem to align particularly well with the capabilities of the human brain. "Implicit learning refers to situations in which complex information is acquired effortlessly… and the resulting knowledge is difficult to express verbally…Implicit learning has educational and even evolutionary value inasmuch as it enables organisms to adapt to new environments by listening, observing and interacting with the objects and people encountered there, even in the absence of formal pedagogy or a conscious effort to learn" (Bransford et al., 2006, p19-20). Hutto (2008) argues that implicit learning can account for many basic human accomplishments, including pre-linguistic use of tools. Implicit learning is being studied from a cognitive neuroscience perspective. Some commentators see this as a distraction from research on informal learning (as studied by anthropologists) and formal learning (as studied by educational researchers). We join Bransford and colleagues in suggesting that powerful new insights into learning are likely to emerge from studying novel combinations of implicit, informal and formal learning. TEL has a particularly strong contribution to make, insofar as it can be used to create environments within which complex abstract ideas can be rendered perceptible to, and manipulable by, the powerful processes implicated in implicit learning.

Clearly, learning has to be understood in terms of a complex set of phenomena, entailing multiple processes and agents. TEL design cannot subscribe to the folk psychological view that sees teaching and learning as merely the transmission and reception of information.

That said, we also think it is useful to distinguish between *learning* – which we take as a label for a set of embodied psychological processes which lead to greater competence or understanding – and *studying* – which is a useful descriptor for a set of real-world activities in which people engage, for the purposes of intentional learning. As well as such psychological processes as problem-solving, reflection and mental rehearsal, studying includes activity in the real world. It includes such things as searching for information on the WWW, browsing library shelves, talking to other students or teachers, finding one's lecture notes, writing essays or project reports, planning a revision schedule, and so on. This is worth saying, because educational design needs to support study activities – a student's work in the world – not just the inner psychological processes of learning (Goodyear, 2000).

TECHNOLOGY-ENHANCED LEARNING

TEL is proving an attractive term because it is open to a very broad range of interpretations – it is not restrictive with respect to either types of technology or pedagogical approaches. We use it to cover all those circumstances where technology plays a significant role in making learning more effective, efficient or enjoyable.

Many different types of technology can be used to support and enhance learning. "Technology" in its broadest sense can include both *hardware* – such as interactive whiteboards, smart tables, handheld technologies, tangible objects – and *software* – e.g. computer-supported collaborative learning systems, learning management systems, simulation modeling tools, online repositories of learning content and scientific data, educational games, web 2.0 social applications, 3D virtual reality, etc.

In terms of hardware, technology continues to change dramatically. The cost of hardware has decreased significantly while its raw performance has improved exponentially. Typical examples of this trend are the technically brilliant and innovative small machines like MIT's OLPC (OneLaptopPerChild) or Intel's classmate PCs, which have appeared as missionaries of educational change in developing countries. In addition to PCs, schools and other organisation have been investing in what might be called 'smart furniture'. Interactive whiteboards are one example, but designers are also adding intelligence to classroom furniture in other ways – such as in smart tables that indicate who, in a group, is doing most of the talking (see BECTA, 2006; Bachour et al., 2008).

In addition to "traditional" desktop computing, where learners reach into a digital educational world via the screen, nowadays electronically embedded physical artifacts or tangible devices enable new types of learner interaction, i.e. full body, haptic, and spatial (Fishkin, 2004). Designing tangible interfaces requires not only designing the digital but also the physical space, and their interrelations within hybrid ensembles that can facilitate individual and social interaction. An example of the use of tangible interfaces for collaborative learning in and outside the classroom is the KidStory project, which aimed to develop technology to support children's group storytelling activities using various tools such as crayons and paintbrushes anywhere on an infinite 2D drawing surface (Stanton et al., 2001).

Also, software technology is changing and is becoming more net-based. As a result, new uses of software technology are emerging. These can enhance student learning, prepare students for effective technology usage in their prospective workplace and/or enable staff to be more productive (Chickering & Ehrmann, 1996).

Thus, designers are investigating what characteristics make technologies effective vehicles for education (Becker, 1994). The key word is "affordances". Technology affords a range of opportunities that can transform the learning process, offering enhanced possibilities for knowledge and skills acquisition. It does not determine or control.

Several taxonomies of technologies for learning have been proposed (Bruce & Levin 1997; Jonassen, 2000; Chickering & Ehrmann, 1996; Conole et al., 2004). For example, we can think of tools and systems for reading, thinking, communicating, and acting in the world:

– *Technologies as media for accessing and studying learning material.* Software systems like Learning Management Systems (e.g. Blackboard, Moodle) or Learning Objects Repositories (e.g. MERLOT) are being widely used for the dissemination/ acquisition of educational material in various formats.
– *Technologies as media for learning through inquiry*. One example is the WISE learning environment, which has been developed in Berkeley, where learners examine real world case studies and analyse current scientific controversies (http:// wise.berkeley.edu/). STOCHASMOS is a web-based learning environment developed at the University of Cyprus, which allows learners to investigate, organise and interpret complex and diverse scientific data and phenomena (http://www.stochasmos.org). Of course, simulation environments like STELLA, Stagecast Creator, Cabri, have been effectively used in learning environments.
– *Technologies as media for learning through communication and collaboration.* Several computer-supported collaborative learning (CSCL) systems, such as CENTRA, DimDim, Synergeia, CoolModes, have been developed to facilitate synchronous and asynchronous collaborative learning tasks. Nowadays, wikis, blogs as well as 3D shared worlds like Secondlife, ActiveWorlds are being extensively used in learning scenarios for various courses (Alexander, 2006).
– *Technologies as media for learning through construction.* Various software tools have been developed for enabling learning by doing. Typical examples are lego-like logo robots (Turner, 2006). Learners build robots out of LEGO pieces, using not only the traditional LEGO building bricks but pieces like gears, motors, and sensors. They also build complex computer programs by “snapping together” Logo commands thus adding behaviour to the LEGO.
– *Technologies for learners’ assessment.* Several freeware and commercial self-assessment tools (e.g. HotPotatos, Question Mark Perception) have been designed for assessing learners’ knowledge. Nowadays, there is a tendency to build tools that allow new methods of evaluations such as Electronic Portfolios which offer capabilities for storing, displaying and reviewing/grading learners’ work in a variety of formats (Meyer & Latham, 2008).
– *Technologies for digital and multimedia literacy.* Various tools have been designed for supporting learning through expression using multimedia such as tools for video editing and annotating, image processing, web comics creation, and so on (Goodman, 2003; Gutierres Martin, 2003).

The role of technology is to direct, foster thinking and facilitate the acquisition of higher order skills. The challenge is to creatively use technologies by focusing upon their affordances. In a well designed technology-enhanced learning environment learners will engage in the process of manipulating information and critical thinking as well as expressing and sharing their knowledge to peer-learners.

DESIGN

We use the term ‘educational design’ to mean the set of practices involved in constructing representations of how people should be helped to learn in specific circumstances.

In formal education, a central role tends to be given to ‘the teacher’. Teaching is a hybrid activity, which typically involves a mix of advance planning, interactive teaching, giving feedback on students’ work and reflection. Popular images of teaching foreground its interactive aspects – the teacher is seen as a person who orchestrates activity in a classroom, provides explanations of ideas and techniques – sometimes at considerable length – and, when time allows, engages in individual conversations to help solve students’ problems (Calderhead, 1984; Bligh, 2000; Davis, 2004). While all these aspects of the role are important, we detect a shift in emphasis – one that mirrors a shift in the sense of what students ought to be doing to learn most effectively.

In short, as images of ‘good learning’ resolve around the centrality of what learners *do* – on the quality of their mental activity – so, images of teaching resolve around the design of good learning tasks, and the design and management of supportive learning environments. The emphasis shifts from teaching-as-exposition and teaching-as-interaction to teaching-as-design. This can be seen in the work of teachers at all levels – school to university – and is proceeding most rapidly in situations where students are engaged in various forms of inquiry-based learning (Levy et al., 2009). Here, for example, the teacher’s main work involves setting productive, appropriately challenging inquiry tasks, ensuring that students have the tools and resources they need to make a success of each task (including opportunities for group activity), and then discretely monitoring progress. This strand of teachers’ work has to be planful – ideas about good tasks have to be thought through carefully; care has to be taken over identifying and setting in place the necessary tools and resources, and over helping students organise their work – individually, in small groups or teams, or as some kind of learning community. We see ‘teaching-as-design’ as an important but rather neglected, even shadowy, kind of educational work. It is recognised in some parts: course and curriculum design and the design of reliable, valid assessment tasks have long been on the teaching agenda. But they are rarely seen as part of the day-to-day work – they are more for specialists in assessment or senior curriculum leaders, and they happen relatively infrequently. We use the term ‘teaching-as-design’ to draw attention to the regular designerly work involved in teaching – it is growing in frequency and importance, but is not yet properly supported, with time or tools or intellectual resources (Fink, 2003).

Teachers are not the only people who engage in educational design. Within school systems, one finds specialist staff involved in creating new learning resources, as well as reshaping courses and curricula. With the widespread take-up of ICT, many school systems have a cadre of staff involved in technical support but also in helping customise ICT for local educational purposes. In universities and colleges, as well as in corporate training, there is a well-established profession of instructional design – involving specialist staff who advise teachers and teaching teams, and collaborate in various combinations to help produce learning tools and learning resources. At the university level, in particular, the acquisition of enterprise-level learning management systems (also known as virtual learning environments), such as Blackboard and Moodle, has generated a need for specialists with instructional design and ICT skills to help mainstream teachers make effective use of the LMS investment (Keppell, 2007).

We are drawing attention to two related shifts in mainstream educational practice. A shift towards ideas about good education that are centered on the quality of the learner's activity is intersecting with a trend towards greater use of ICT. The combination – activity-centered TEL – creates a growing demand for good educational design.

A robust, contemporary conception of educational design needs to recognise that: (a) good design is complex and takes skill, experience and time, (b) it includes the design of good learning tasks, but also the design of supportive, convivial learning environments, (c) design works indirectly: learners have scope to adapt, customise and invent, (d) it operates at various scale levels – from the detailed functionality of a tool or the interface to an e-book right up to the institution-wide infrastructure. Vertically coherent educational design is needed to ensure that what learners need to do – at a micro level – aligns with the nested set of learning spaces in which their activity is set. (This is a crucial point. It is very hard, in complex educational institutions such as universities, to establish a shared understanding of the interactions between pedagogy and infrastructure at all the key levels in the decision-making hierarchy. Crudely put, it is a rare director of property services who understands the psychology of learning, or what this implies for the affordances of built space.)

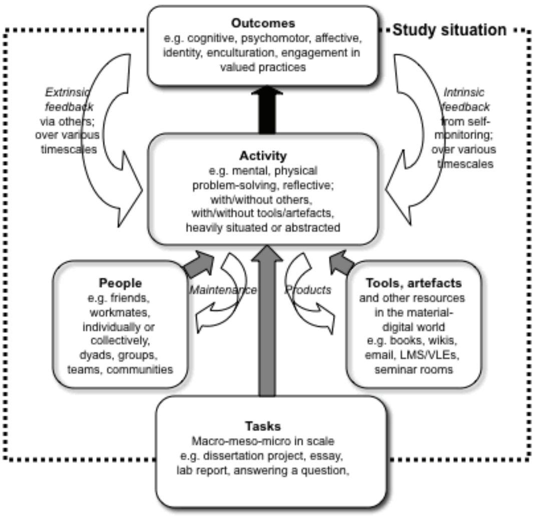

Figure 1. The problem space of educational design.

Figure 1 helps capture what we mean by the problem space of contemporary educational design. It is an elaboration of the model in Goodyear (2005). The model gives a central place to student activity – to the mix of psychological and physical activity through which each student responds to their current task. Earlier in the chapter, we distinguished between study and learning. We place study activity at the centre; learning processes are tightly bound up within the activity, but are not the same as the activity. Learning and its outcomes are – from a functional educational perspective – the things that matter. Productive activity enables valued learning.

Productive activity does not take place in a vacuum. The physical and social situation in which it is set can play a subtle but decisive role in shaping activity and its outcomes (Greeno, 2006). Of course, one can think – for a while – without noticing the intrusion of the physical world or other people. But this is rare. Much of what we do involves interaction with the physical world and/or other people. This may be as simple as doodling, jotting down keywords, flipping through the index of a book, or Googling a definition. It may be no more than an exchange of grunts with a team mate, as you notice a snag in what you thought was a solution. But the constraints and affordances of the physical and social world can be *very* influential in shaping activity – limiting access to useful information (or bombarding the senses); providing opportunities for debate, that reveal the rich variety of other people's beliefs; giving a sense of being a useful, if peripheral, member of a global intellectual community, and so on. For these reasons, *Figure 1* insists that design has three main components: the design of good learning tasks (which stimulate and help structure, but do not wholly determine the students' activity), and design of the physical and social context(s) for students' activity.

We said that educational design is best understood as an *indirect* practice. It does not directly create activity. Rather, it creates good learning tasks – as blueprints for activity. It identifies useful tools and resources, and has things to say about necessary infrastructure, but it leaves the detail of configuring the learnplace to the student. In the same vein, it can – and often should – make recommendations about how students should work with others (in pairs, in teams, as a community of inquiry, on their own; with similarly able students, or in mixed ability groups, etc). But students also make their own decisions about who to work with, and how. They co-configure the social and physical context; they adapt learning tasks to meet their needs. They co-create the activity systems.

Design takes time. Even if one simplifies the challenges and opportunities sketched above, design remains a demanding task. It is characterised by various kinds of experimental thinking – some would say trial and error. It involves imagining other people's learning: how they will respond to a task, where they will work, with whom, how, using what resources, over what timescale, and so on. There are echoes of the architect's imagination – how will people respond to a new built space; how will their activity settle within it; will it make them happier, more stressed, able to focus or subject to distraction? Design is iterative. It rarely 'comes right' at the first attempt. It involves 'wicked' rather than well-formed problems (Kirschner et al, 2002; Ertmer et al., 2008; Jonassen, 2008).

Because it is cognitively demanding, design usually needs tools and external representations – designers need to ‘offload’ parts of the problem by committing partial solutions, promising ideas, etc to paper, or screen (see e.g. Schon, 1983, Ch3; Bell, 1999; de Vries & de Jong, 1999; Michell, 2003; Buxton, 2007). It’s especially hard for the lone teacher to do good design work. Designs are improved through talk and reflection, criticism and explanation (Levy et al., 2009). Design works best in teams, to which people bring a range of complementary skills and knowledge.

All of this raises questions about whether and how educational design activity can be improved. We are convinced that it *can* be improved, and that the patterns-based approach has remarkable potential for supporting such improvements. The iterative, demanding, time-consuming nature of design means that it is possible to imagine such things as design guidelines, knowledge and experience being used (embodied in books, tools, automated aids, etc) – in a way that is unimaginable if we are thinking about live/interactive classroom teaching. Part of what attracts us to the use of design patterns is their potential *fit* with the cognitive demands and processes of real-world design activity. As we will try to show, they are both action-oriented and educative: they provide scaffolding for decision-making when the designer needs such help, but they also teach more general lessons (Goodyear & Yang, 2009). Also, as we will see, the possibility of combining patterns in pattern languages that traverse micro to macro scale design issues, means that they can be used to align the design and other decision-making work of people who have responsibility for the management of learning environments at all scale levels, and across virtual and material spaces.

On the downside, we would have to acknowledge that educational design, as typically practiced in formal education, is too rarely accompanied by the use of efficient design representations. Architects use sketches – many iterations of them – because it helps to be able to visualise aspects of a solution and it is much more efficient to alter a sketch than a building (Schön, 1983, 157-60; Buxton, 2007). One role for computer-based educational design tools is to insert an editable representational layer between the ideas in the designer’s mind and the world inhabited by the learner (see e.g. McAndrew et al., 2006; Botturi & Stubbs, 2008; Derntl & Motschnig-Pitrik, this volume). But much of what teachers currently do, we suspect, involves making strong, premature commitments in the world, rather than using intermediate design representations. Scope for visualising the learners’ future experience, reflecting upon it, and editing designs, is thereby reduced. To the extent that our suspicion is correct, opportunities for improving educational design – and thereby improving learning – are being lost. Design without periods for informed reflection is hard to improve.

SHARING AND RE-USE

Educators have long been in the habit of reusing learning resources: textbooks, maps in Geography classes, periodic tables of the elements in Chemistry classes, films and videos, etc. As well as these resources, which are used directly with learners, educators sometimes also exchange lesson plans and other, more or less abstract, representations of how to teach.

The ability to share and re-use learning resources, lesson plans and the like has been greatly aided by the Internet. A general label that is now applied to a learning resource that is available via the Internet is a *learning object* (LO). According to IEEE LOM (2001), the term 'learning object' refers to any digital asset of learning material which can be used to support teaching or learning. In order to help people find learning objects that are relevant to their needs, descriptors for learning objects ('metadata') have been created and standardised. Standardised metadata makes it easier to discover, re-use and combine learning objects.

Currently there are a number of online learning object repositories (LORs). They serve several purposes, such as browsing and searching in a catalogue of LOs, booking/purchasing LOs, annotating/commenting on LOs, and contributing LOs. Among the best-known LORs are MERLOT (http://www.merlot.org), CAREO (http://careo.netera.ca) and COLIS (http://www.edna.edu.au/). Unfortunately, some of the work around LORs and reuse has led to a simplistic view that courses can be created by combining LOs, just like connecting Lego bricks (Koper, 2005). In fact, when teachers design or plan a lesson or a course they do not merely decide on the content and learning object resources but also need to specify the sequence of the tasks that the learner should tackle, within the constraints of the technology-enhanced learning environment.

This is why an interesting shift in learning design occurred: to view sequences of learning activities as reusable objects – as templates that teachers could access and adopt/adapt to create a course. Learning design modelling languages such as IMS Learning Design (IMS LD 2003), E2ML (Botturi, 2006) and LAMS (Dalziel, 2003) have been proposed to formally describe the learning design. This is regarded as a time-ordered series of activities to be performed by *learning actors* (learners and teachers) within the context of a technology-enhanced learning environment that consists of reusable LOs and services. With the wide adoption of such learning design specifications, a number of tools have been developed to help teachers/designers to create sequences of learning activities associated with tools and resources (Conole & Fill, 2005; Paquette et al., 2005).

However, these learning design specifications cannot illustrate clearly the pedagogical rationale of the design. Learning design patterns can be a solution to this problem since they can document designers' tacit knowledge and experiences and offer examples in a form that practitioners can apply in their own teaching context. How to combine formal (and computable) learning design specifications with learning design patterns is still very much a matter for debate.

DESIGN PATTERNS AND PATTERN LANGUAGES

The source of all the work on design patterns and pattern languages is the mathematical and architectural writing of Christopher Alexander, most notably in the trilogy of books he and his team produced in the late 70s (Alexander, 1979; Alexander et al., 1975, 1977).

There is an often-quoted definition of a pattern, with which we will start, though it needs some explanation. *A pattern is a solution to a recurrent problem, in a context.* In Alexander's own words, a pattern …

> "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander *et al*., 1977, p.x).

What is a solution?

A potentially confusing aspect of this definition arises from the way that problem and solution – especially solution – have come to mean different things in different areas of professional practice. In many fields of design practice, a solution is an artefact – it is a new thing, such as a door hinge or the atrium of a building. It may be quite simple (like a bottle opener), or very complex (like an airplane). In product design, any new thing that satisfies the design requirements can be described as a solution. In other fields of practice, a solution is a method rather than a thing. It says what has to be done.

The confusion is actually exacerbated by some ambiguities in Alexander's explanation of patterns (op. cit. pp. x-xi). He describes a solution as "the heart of the pattern – which describes the field of physical and social relationships which are required to solve the stated problem, in the stated context" (p.xi). We take this to refer to a thing (simple or complex) or a state of affairs. However, Alexander also says that a solution must be stated as an instruction – "so that you know exactly what to *do* to build the pattern" (p.xi, our emphasis). The mixing of method and artefact can be seen in many Alexandrian patterns. Here for example is the problem and solution text from Pattern #179 'Alcoves':

> "No homogeneous room, of homogeneous height, can serve a group of people well. To give a group a chance to be together, as a group, a room must also give them the chance to be alone, in ones and twos in the same space…
>
> Therefore:
>
> Make small places at the edge of any common room, usually no more than 6 feet wide and 3 to 6 feet deep and possibly much smaller. These alcoves should be large enough for two people to sit, chat, or play and sometimes large enough to contain a desk or a table." (op. cit., pp829-832).

The combination of method and artefact is embedded in that little word 'make'. This may seem trivial; indeed it may escape notice. But the lack of clarity about whether a pattern is a recurrent form or a set of steps – an omelette or a procedure for making an omelette – turns out to confuse people hugely in areas like education. A further source of potential confusion is that Alexander uses the term 'pattern' to refer to sets of arrangements in the real world, as with the alcoves, *and* to his particular way of describing these recurrent forms. (He uses the word 'pattern' to refer to both the territory and the map, if you will.)

The format of an Alexandrian pattern

Alexander's way of presenting a pattern is quite distinctive, though it is not used universally by those who have picked up his core ideas. In his own words again:

> "…each pattern has the same format. First there is a picture, which shows an archetypal example of that pattern. Second…each pattern has an introductory paragraph, which sets the context for the pattern, by explaining how it helps to complete certain larger patterns. Then there are three diamonds to mark the beginning of the problem. After the diamonds, there is a headline, in bold type. This headline gives the essence of the problem in one or two sentences. After the headline comes the body of the problem. This is the longest section. It describes the empirical background of the pattern, the evidence for its validity, the range of different ways the pattern can be manifested in a building, and so on. Then, again in bold type, like the headline, is the solution – the heart of the pattern….another three diamonds…show that the body of the pattern is finished. And finally…there is a paragraph which ties the pattern to all those smaller patterns in the language, which are needed to complete this pattern, to embellish it, to fill it out." (op. cit., pxi).

Here is an example of a pattern, described using the Alexandrian format, but taken from the world of education, rather than from architecture. We do not have space to give a full treatment of 'the body of the problem', which can be of several pages. Neither will we use pictures or diagrams. But the example should help the reader get more of a sense of how educational design patterns and pattern languages might work. The pattern we have chosen is the WRAPPER pattern, which describes a role that can be very useful when students are engaged in discussion tasks (Goodyear, 2009).

WRAPPER

> This pattern defines a role that is useful in a number of Group Task Patterns: notably DISCUSSION GROUP.
>
> ♦ ♦ ♦
>
> **In an active, spirited discussion, it's not easy for everyone to keep track of ideas and conclusions. Most people are concentrating on what they want to say next, rather than reflecting on, and trying to commit to memory, things that have been said. Good ideas get lost, and in the long run this can be demoralising.**
>
> *Body text explaining the basis of the pattern normally goes here.*
>
> Therefore:
>
> **Give one or two students the role of discussion WRAPPER. They should take notes during the discussion, capturing points of importance. These may be ideas or key arguments that shaped the discussion. They may be conclusions or decisions about the direction of future work. Brief the**

WRAPPER so that they focus on key ideas and don't try to record the whole history of the discussion. The WRAPPER should have five minutes or so at the end of the discussion to present their 'wrap'. Brief the other participants so that they know it's OK to ask the WRAPPER to note something down.

♦ ♦ ♦

Patterns needed to complete this pattern include: NOTEPAD, WRAP. SCRIBE is an associated role.

The wrapper pattern is self-explanatory. As an example of the Alexandrian form, we should just point out that DISCUSSION GROUP is a pattern that provides a context for the WRAPPER pattern. The WRAPPER pattern, in turn, can be a context for the NOTEPAD and WRAP patterns. (Looked at the other way up, the NOTEPAD and WRAP patterns are embellishments of the WRAPPER pattern, which in turn is an embellishment of the DISCUSSION GROUP pattern.) The text in bold, beginning 'In an active, spirited discussion…', is the problem statement, and the text in bold, beginning 'Give one or two students the role…', is the solution statement.

The WRAPPER pattern makes some sense on its own, but gains explanatory and practical power when presented as part of a pattern language. A pattern language can be seen as a set of patterns which are connected by being either contexts or embellishments for each other (see *Fig 1.2*). A pattern language is a way of gathering together a set of patterns such that a project of worthwhile scale can be tackled. Alexander's examples include building a house, or an extension to a house, or a porch. But he also uses the term 'pattern language' to refer to the whole collection of 253 patterns in his 1977 book. This ambiguity does not seem to us to be quite so problematic. In education, there must be a strong sense that the set of patterns is indefinitely extensible, or virtually so. That said, it is helpful to focus on pattern languages (in the more restricted sense) that help with recognisable kinds of educational projects – such as creating a new course, or moving a course from face-to-face to blended mode.

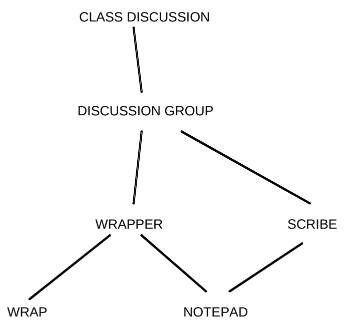

Figure 2. Seeing the WRAPPER pattern as part of a pattern language.

There have been quite a number of attempts to use a patterns-based approach in areas of human endeavour outside architecture. Some of the best work in education, particularly in relation to technology-enhanced learning, has been carried out by the colleagues who have written the chapters of this book. There was also some early work on pedagogical patterns, led by people who taught software engineering and who had been involved in developing patterns for object-oriented software design (Sharp et al., 2003). More recently, patterns and pattern languages have been developed in various branches of work on human-computer interaction (e.g. Graham, 2003, Tidwell, 2006; Dearden & Finlay, 2006), organisational change (e.g. Coplien & Harrison, 2004) and distributed social activism (e.g. Schuler, 2008).

QUESTIONS OF VALUE

Some of the intellectual roots of work on educational design patterns lie in the older field of instructional design. One reading of instructional design positions it as a rational, technical enterprise, concerned with optimising learning and instruction through the application of objective scientific principles. This reading of instructional design does not foreground questions of *value*, other than the privileging of instructional efficiency and effectiveness. This muted treatment of values can also be found in areas of TEL design, including some of the work aimed at providing tools that help teachers as designers. As we mentioned earlier, one sometimes comes across claims that a method or tool is 'pedagogically neutral', as if that were unquestionably a good thing.

We mention this because Alexander's writings are suffused with value commitments. Patterns and pattern languages are not just neat formats for communicating solutions to problems: patterns have a moral component (they are meant to make life better); they are intended to enhance coherence in the things that are made from them; they are meant to be generative – empowering people to strengthen coherence in the things and places they create (Alexander, 1999, p. 74). Much of Alexander's work has been a search for the qualities that draw us to good buildings and to other places that make us feel more alive and whole. He is highly critical of many features of modern industrial life, seeing the outcomes of 'mechanical' design as squashing and eroding those things that make us human.

We think it would be inappropriate – to put it mildly – to adopt Alexander's patterns as mere communicative tools, without acknowledging the way they intertwine with deep considerations of value. In earlier work (Goodyear et al., 2004), we drew attention to some of the jagged edges of modern 'industrial' education and talked about how the use of TEL, if well thought through, could lessen the damage. We might now go further and say that *good* TEL design is characterised by a commitment to helping people create circumstances in which learning can be experienced as coherent with what is most deeply valued in the rest of life, as a source of pleasure, growth and transformation. On this view, *bad* TEL design leads to fragmented, alienating and/or dispiriting experiences.

OVERVIEW OF THE CHAPTERS

It is possible to dip into the chapters in any order, though each of the chapters assumes the reader has been introduced to the foundational ideas and terminology presented above. That said, there *is* a logic to our sequencing. We get underway with a more extensive examination of architectural sources of inspiration (Chapter 2), but then offer a rich sequence of examples of work that colleagues have been doing with patterns in the complex field of computer-supported collaborative learning (CSCL). Design patterns and (more or less explicit treatment of) CSCL provide a connecting theme for chapters 3 to 7, though as we shall explain shortly, each of the chapters also illuminates a unique set of educational, design and technical issues. Chapters 7, 8 and 9 sketch some of the bridges that link patterns-based work in software engineering with patterns-based work in the area of TEL. Software development for TEL is notoriously difficult and these chapters simultaneously explain some of why this is so, and point to ways in which patterns-based development may turn out to be particularly productive. Chapter 10 begins a sequence of chapters that focus more strongly on the educational aspects and applications of TEL design patterns: looking at evaluation, the treatment of pedagogical rationales, and the language used in networked learning. Chapters 13 to 17 are linked by interests in organisational issues: from the use of patterns in organisational learning to methods and tools for sharing the work of pattern creation.

Let us now turn to a quick overview of each of the chapters.

Andrew Gibbons' chapter (Chapter 2) can be seen as an extension of the architectural work on instructional design layers that he has written about with Clint Rogers (Gibbons & Rogers, 2009). The conceptual separation of designs into discrete layers is a useful way of handling complexity without resorting to reductionism. Gibbons discusses a number of key issues, desiderata and important functions in relation to each of seven design layers, and then identifies patterns to address each of these design considerations. There is not enough space to go into details of the 77 patterns listed. In our view, a significant part of Gibbons' contribution is that it helps organise perspectives on educational design, not least through identifying some of its main dimensions.

In Chapter 3, Davinia Hernández-Leo, Juan Asensio-Pérez, Yannis Dimitriadis and Eloy Villasclaras-Fernández describe the derivation, architecture and application of a set of design patterns tuned to the needs of computer-supported collaborative learning (CSCL). Research in CSCL has shown how it *can* have considerable educational benefit, but that slips in implementation can reduce these benefits considerably. One way of strengthening the implementation, and associated benefits, of CSCL is through the use of scripts, which help structure students' activity and ensure they have access to the tools and resources they need. Hernández-Leo et al. show how patterns and pattern languages for CSCL can be used to generate CSCL scripts for specific courses or programs of educational activity. A particular strength of the chapter comes from its attention to the ways in which patterns can be combined: they offer a number of principles underpinning logical strategies for combining patterns.

In Chapter 4, Stephan Lukosch and Till Schümmer provide an overview of their work developing patterns and pattern languages in the area of computer-mediated interaction, focussing on the particular domain of CSCL. Their chapter is specially useful in alerting us to the need for integrating many different kinds of patterns in the development of CSCL/CMI environments. Some of the necessary patterns are quite generic and apply across a broad range of social or technical design areas. Others are much more specific to learning interactions. The important thing is that designers and developers, and sometimes end users, need to manage complex combinations of these different kinds and levels of patterns. Conceptual clarity is a necessity, not a luxury, in this regard.

Franca Garzotto and Caterina Poggi (Chapter 5) explore a specific and still little-known areas of CSCL – namely, collaborative learning in 3D virtual worlds (such as Second Life). They rightly identify the design of 3D CSCL environments as complex, and show how design patterns can be used to capture and share relevant design knowledge. The authors draw on a wealth of experience of creating and evaluating 3D CSCL environments. They show how patterns can be used as a common way of representing experience about quite diverse (but complementary) design areas. Garzotto and Poggi's example patterns are concerned with (i) learner experiences and (ii) the affordances of the 3D virtual world being designed as a space for experience. This nicely illustrates the way that different kinds of research-based design knowledge can feed into different layers or components of the design problem, while all the time using the common patterns-based representational format.

Christian Voigt (Chapter 6) is also interested in the use of design patterns to help support CSCL, but his chapter moves the discussion up a level by focussing on how we might best understand *context* in relation to patterns. Drawing on Star's 'boundary objects' and Engeström's 'activity systems', Voigt argues that understanding the functioning of *patterns in use* is key to working out the implications of context. Voigt's chapter is especially useful for thinking about some of the dynamics of CSCL, e.g. as student groups form, develop norms, run into difficulties, etc. Patterns can sometimes take on a static feel and Voigt's chapter is good at breathing life into them.

Rafael Calvo and Aiman Turani (Chapter 7) use their synchronous CSCL system Beehive as a vehicle for showing how educational design patterns can be linked to software components to create TEL frameworks. Following terminological usage in software engineering, a TEL framework can be thought of as an integrated combination of design patterns and software components, where the design patterns encapsulate design experience, guidance, etc and the corresponding software components mean that chosen designs are runnable. Their Beehive example draws on some of the seminal work of Morten Paulsen, who identified a number of successful CSCL techniques, together with their requisite resources. Calvo & Turani's work builds on Paulsen in a convincing demonstration of how to move from experience to design patterns to runnable CSCL software.

César Moura, John Hicks and Alain Derycke (Chapter 8), like Calvo and Turani, are interested in connecting patterns to software, but their argument is somewhat different. Moura et al describe work associated with the development of the

MDEduc system, focussing particularly on the role of *informal representations* in the design and development of TEL software. They see pedagogical patterns as interesting examples of such informal representations. They make the compelling point that maintenance of informal representations, after the implementation of TEL software, is potentially very valuable. This flies in the face of some software development thinking, where informal representations are seen as merely a means to the end of creating software, and are therefore disposable. Moura et al rightly argue that informal representations do not just help with getting the design right, but also with getting the right design. By going back to the informal representation – in this case a pedagogical pattern or pattern language – designers and developers can check whether the original design ideas were actually as good as people first thought, whether they could be improved upon, whether they *quite* capture best practice.

Chapter 9 (Andreas Harrers and Alke Martens) shows how patterns and pattern languages can help bridge between the worlds of pedagogy and systems design. Harrer & Martens take us into some high-level design and implementation issues that are relevant to complex TEL systems, including intelligent tutoring and collaborative learning systems. This work forges another set of connections between the mainstream software engineering tradition of patterns-based development, and work on pedagogical patterns. The chapter hints at some interesting emerging tensions – over desiderata for design patterns – between specialists in different areas, as well as showing how communications between different specialisms might be improved.

In Chapter 10, Petros Georgiakakis, Simeon Retalis and Yannis Psaromiligkos shift our attention to issues of TEL evaluation. They make the point that expert TEL evaluators are scarce and expensive, and that there are strong arguments for upskilling, and scaffolding the work of, less experienced and non-specialist evaluators. The authors' DEPTH evaluation methodology uses design patterns as a way of making the TEL knowledge of experienced evaluators available to novices. The chapter describes a case study in which a group of novice evaluators made successful use of the DEPTH approach. It can be argued that the future of TEL is one in which user/learners, teachers and others will be involved in loose collaborations through which TEL environments are co-configured and customised. In such circumstances, it makes a great deal of sense if *everyone* involved can play a role in the ongoing evaluation and improvement of TEL environments.

Fiona Chatteur, Lucila Carvalho and Andy Dong (Chapter 11) provide a worked example of an elaborated structure for a design pattern, with the intention of providing stronger and more explicit links between pedagogical theory and design advice. They work from published literature towards the design pattern, and nicely contrast this methodology with 'reverse engineering' or abstracting patterns from successful practice. A notable feature of their approach is the space and care given to incorporating what might be called 'deep pedagogy'. They are unconvinced by the treatment of pedagogical explanation and justification in much of the existing patterns-based work, and use an extended pattern format to ensure that the subtleties of pedagogical reasoning can be captured and shared.

Dai Fei Yang (Chapter 12) explores some similarities and synergies between the application of Systemic Functional Linguistics (SFL), to analyse language use, and the construction of design patterns to capture valued educational practice. In many TEL situations, interaction between teachers and students is mediated through online texts, so understanding the subtleties of language use can provide some penetrating insights for those wishing to capture teaching expertise in pattern form. Yang also draws some convincing analogies between Alexander's concerns about the alienating effects of industrial architecture and the alienating effects on students of industrial teaching methods.

In Chapter 13, Michael Derntl and Renate Motschnig-Pitrik reflect upon their experience of crafting and using design patterns in the context of teaching university-level informatics and computer science courses. This is a powerful chapter because it draws on deep, hard-won experience of working seriously with design patterns, and the authors' reflections are also informed by a broader understanding of issues in process modelling, visual languages and educational evaluation. The authors insist upon the importance of a firm and clearly-articulated value base, on which to construct educational designs, and argue strongly for a pragmatic view on design patterns – recognising strengths and limitations, and grounding design claims in firm evidence from student evaluations. The Vienna collection of design patterns, in our view, represents one of the most significant achievements to date in this field.

Winters, Mor and Platt (Chapter 14) have also been working on the creation of a pattern repository and offer a compelling illustration of the argument that tools and community practices are interdependent. They describe the d2n approach that they adopted to help a distributed, multidisciplinary community of teachers, researchers and technical specialists collaborate on the development of an extensive set of mathematics education patterns. The actual learning patterns work and its outcomes have been documented elsewhere (see e.g. Pratt et al., 2006). In this chapter, the authors focus on some of the tools they used to support collaborative design work: especially on ways of interrogating and working with the shared repository of evolving patterns. Chapter 14 is particularly instructive because of the seriousness with which it treats distributed design methodology – forging firm links between the tasks and social practices of design, on the one hand, and the functions and affordances of the design database tools, on the other.

Till Schümmer (Chapter 15) explores the idea of a pattern scout as an aid to organisational learning, in the sense of someone who helps members of a community of practice (or a company, or some other kind of formal organisation) to identify and document best practice. Drawing on Schön's notion of reflective practice, Schümmer identifies one of the key difficulties of sharing professional knowledge in rapidly changing areas – that much of what turns out to be the most valuable knowledge is tacit, hard and time-consuming to articulate, and contestable. Schümmer uses the idea of *protopatterns* as ways of capturing and sharing emerging practices, prior to the point at which repeated successes or empirical evidence give the practices the solidity or status of established patterns.

In Chapter 16, Gráinne Conole & Chris Jones shift our attention up a level: to institution-wide issues. They are particularly concerned with methods of sharing educational design ideas during times of institutional change. Their example is situated in the UK's Open University, and relates to the introduction of a new institution-wide virtual learning environment (VLE). The chapter explores the complementarity of pedagogical patterns and visual learning design, and offers a detailed description of a tool for visualising designs (CompendiumLD) that is being trialled in the OU. Conole & Jones locate their work at the meso-level of institutional activity: where top-down and bottom-up processes meet, and institution-wide structures interact with local actions. Among other valuable insights, this underscores the importance of seeing local design as constrained by the structures and processes that are created and maintained at higher levels in the institution. Design rarely works on a 'greenfield' site.

In Chapter 17, Maria Zenios and Christine Smith extend this exploration of institution-level issues, using the idea of an 'e-learning centre' or a 'TEL centre'. Zenios & Smith use this label to identify a unit, within a larger organisation such as a university, that has responsibility for serving the learning needs of students and staff, and especially for helping with educational innovation that involves TEL. Their survey-based analysis of the requirements that universities place on e-learning centres underscores the need to manage a complex set of competing priorities – a task for which organisational design patterns are well-suited. They identify ten areas that require attention from centre management – from vision to benchmarking – and sketch some design patterns that suggest ways of balancing some of the associated tensions.

Finally, Symeon Retalis, Agnieszka Bachfischer and Peter Goodyear review some of the achievements of the field and identify some opportunities for further research (Chapter 18).

CONCLUDING COMMENTS

Christopher Alexander's vision is one of enabling people to regain control of important aspects of their lives, including the ability to help imbue their environment with qualities that make the experience of place more pleasurable and coherent. His exploration of the qualities that make places 'alive' has spanned nearly half a century (Alexander, 1964; 2006). Our work exploring the qualities of good learnplaces – physical, digital, hybrid – has really only just begun. Early results look promising, as we hope this collection will demonstrate.

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ANDREW S. GIBBONS

2. A CONTEXTUAL FRAMEWORK FOR IDENTIFYING INSTRUCTIONAL DESIGN PATTERNS

INTRODUCTION

Alexander (1964, 1977, 1979) sees designing as a process of selecting and arranging abstract patterns, and then giving specific dimension, texture, property, and detail to the resulting integrated abstraction. Other writers have also described this aspect of designing; they include: Brand (1994), Schön (1987), Kroes (1992), Polanyi (1958) and Vincenti (1990).

Polanyi (1958) describes a construct called the 'operational principle' – an abstract structuring of forces that accounts for 'how [a] mechanism works' (p. xx). Polanyi identifies the operational principle as a central structuring principle of designs. Vincenti (1990) gives numerous examples, from aeronautical design, of how operational principles lend a design problem an inner structure that leads more directly to solutions. Kroes (1992) describes how dimensionless, abstract patterns of steam engines, derived from multiple operational principles, are given substance and dimension during the design of a specific engine. Schön (1987) names multiple 'domains' of a design problem – sub-problem solution spaces – wherein named structural elements are formed into a partial solution, which is integrated with other partial solutions to become part of the completed design. Brand (1994) describes similar building design domains – which he calls 'layers'. He describes the practical value of these pattern-supplying layers in terms of longevity, maintenance, and lifetime cost of buildings. Gibbons and Rogers (2009) apply this principle to instructional designs and demonstrate the relationship between layers and design theory (theory of how to design) and instructional theory (theory of how to instruct). Layers (domains) of a design represent functions carried out during instruction.

These ideas together describe a pattern-centered, architectural view of design that is independent of any specific design field and that can therefore be applied to instructional design. Gibbons and Rogers associate their framework of design layers with multiple structural design languages that pertain to designs within each layer (Gibbons, 2003; Gibbons & Brewer, 2004; Waters & Gibbons, 2004). These design languages supply sets of primitive abstractions that can be incorporated into designs.

Increasingly specialized design practitioners learn these structuring languages for their area of design. The shared, public languages become part of the design practitioners' private design languages for problem solving. The public version

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of the languages becomes a tool for defining shared practices, tools, processes, styles, schools of thought, professional organizations, standards, and cultures of practice for designers whose work pertains to the different layers. As a particular technology area advances, professional specialties form and proliferate. Languages within design layers are the primary tool for the formation of communities of practice among designers (Barton & Tusting, 2005). Most importantly, it is these languages that supply the patterns that are integrated together at different levels of specificity and detail – as Alexander describes – to create a design.

PURPOSE

This chapter demonstrates the implications of the Gibbons and Rogers design layer theory for the identification of design patterns for both on-line and off-line learning designs. Briefly stated, the argument is as follows. A single design requires numerous patterns of different kinds, which must be integrated into a larger pattern that is internally self-consistent and coherent. Patterns that are combined into a completed design are expressed using the languages of multiple design layers. A single design cannot be generated from a single pattern. The principle of design layering does not dictate theoretical principles to a designer; on the contrary, it provides terms for expressing designs influenced by any theory. Further, it opens the prospect of developing idiosyncratic terms that, if they are superior, give the designer an advantage. In this way, design layers and design languages supply a much needed link between the architectural aspects of a design and the theoretical principles of learning and instruction, and provide the basis for principled exploration and innovation.

The argument will take the following form: the functional layers of an instructional design will be named and described using terms selected by Gibbons and Rogers. Within each layer, a sampling of the most critical patterns for online and instructor-led learning will be identified and given a rationale to demonstrate the value of layers as a framework for pattern identification.

PATTERNS AND LAYERS

Alexander's pattern languages derive their terms from the naming of spaces (COMMUNITY OF 7000, IDENTIFIABLE NEIGHBORHOOD, SMALL PUBLIC SQUARES) the functions of spaces (BIRTH PLACES, CONNECTED PLAY, SHOPFRONT SCHOOLS), and the qualities of spaces (INTIMACY GRADIENT, INDOOR SUNLIGHT, SHORT PASSAGES). They also describe how social functions overlay spaces (SMALL MEETING ROOMS, SITTING CIRCLE, CHILD CAVES).

Design layers derive their names from a set of minimal functions that must be performed during instruction for instruction to take place. Design languages derive their terms from objects, artifacts, tools, processes, roles, design interactions, and qualities. An instructional design language must be a language for structuring time and symbols as well as space.

Pattern languages and the design languages that reside within design layers are similar in many respects. Some of the most important similarities are described below.

Function-relatedness

Alexander describes how patterns are related to functions:

> So that people will be able to make innovations and modifications as required, ideas about how and why things get their shape must be introduced. Teaching must be based on explicit general principles of function, rather than on specific and unmentioned principles of shape. (Alexander, 1964, p. 36)

Adaptability

Both Alexander and Gibbons and Rogers (2009) expect designers to adapt language constructs to private use. The language user is also expected to participate in the expansion and enriching of the language in both cases. Both warn against freezing languages and turning them into closed orthodoxies:

> Once…concrete influences are represented symbolically in verbal terms, and these symbolic representations or names subsumed under larger and still more abstract categories to make them amenable to thought, they begin seriously to impair our ability to see beyond them…. Caught in a net of language of our own invention, we overestimate the language's impartiality. Each concept, at the time of its invention no more than a concise way of grasping many issues, quickly becomes a precept. We take the trip from description to criterion too easily, so that what is at first a useful tool becomes a bigoted preoccupation. (Alexander, 1964, p. 69–70)

Sequence of application

Alexander and Gibbons and Rogers (2009) describe sequences of influence during language application. In both, the designer may choose any level or layer as an entry point for beginning design. Then, through a natural process, design decisions within the initial layer or level propagate outward, placing constraints and creating design opportunities within other layers or levels. For instance, Alexander holds that region- and town-level designs evolve from many smaller choices and suggests that designers enter design at levels where influence is more certain, such as at the neighborhood level or below. Later in this chapter I will suggest a layer design sequence for instructional design based on personal priorities and suggest that alternative orders of layer selection can be equally valid.

INSTRUCTIONAL DESIGN LAYERS

Gibbons and Rogers (2009) identify seven layers of an instructional design that represent functions carried out during instruction. A complete instructional design is built from abstractions that pertain to the different layer functions. A complete design must specify how the following functions are carried out, whether by live instructors or by technological means:

– *Messaging*: messages, in an unmediated state, must be formed, ready to be given media expression.
– *Representation*: once formed, individual message elements must be mediated for delivery to the learner through multiple media channels. The value of separating message and representation concerns will become clear later.
– *Controls*: the learner must be able to respond to instructional messages, take initiatives and interact with the instruction. This indicates the need for a system of controls through which the learner 'speaks' to the instruction.
– *Content*: the subject matter must be divided into structural parcels of some size and scope that have designer-selected logico-semantic characteristics, and which give affordances to strategic rules.
– *Strategy*: there must be a higher-order decision-making logic that directs the combination of content structures with messaging, control operation, and representation to produce interaction between the learner and the instruction.
– *Media-logic*: there must be directions to govern and execute the acts of either technological tools or live instructors to carry out all of the functions described in the design (strategy, messaging, representation, control, etc.).
– *Data management*: there must be a memory function capable of recording, storing, analysing, interpreting, and reporting data from the learner's instructional history for use in decision making – either by the learner or by the delivery medium.

These functions are typical of virtually all instructional designs. The design of each function takes place using the pattern-rich design languages associated with a particular layer. Therefore, patterns used in instructional designs consist of patterns of knowledge, patterns of strategy; patterns of control and response-making, patterns of interactive communication; patterns of representation, patterns of execution logic; and patterns of data keeping and data use in decision making.

It is the synergy created through the selection of patterns for inclusion in a design that distinguishes mechanical designs from sophisticated and artistic designs – designs Alexander would describe as being 'alive'.

LAYERS AND THE SEQUENCE OF DESIGN

Alexander states that a design language is used in a sequence 'going through the patterns, moving always from the larger patterns to the smaller, always from the ones which create structures, to the ones which then embellish those structures….' (Alexander, 1977, p. xviii). Though he describes this larger-to-smaller order, he also states that 'there is no one sequence that captures [a language]'. This suggests that the order of application of language pattern to a design is, to some extent, a decision of the designer, with the general rule being that skeletal structures are designed first, before their properties, inner structures, and embellishments. (See Kroes (1992) for an example.)

Most instructional design projects come to a designer with existing constraints (e.g., 'I need this on three video podcasts, each no more than 10 minutes long'). These constraints, which are situated within particular layers, condition decisions within all other layers by placing constraints on future decisions. For example, a commitment to the podcast medium rules out the need for computer programming and its associated design structures, but it also automatically includes in the design the need for 'scenes', 'edits', and 'transitions', which are terms specific to the video medium. It can be said, therefore, that the sequence of decision making during design first takes into account the 'givens' of the problem and moves outward from there.

Neither in Alexander's pattern languages, nor in design layer theory, is the order of design fixed at this point, except by the preferences and priorities of the designer. As a basis for making this choice, the designer confronts the question: 'What am I designing?' The answer the designer gives to this question (which is too seldom asked explicitly) largely determines the order or sequence of design from that point.

Gibbons (2003) gives an example of the selection of design priority and design order by describing the typical answers of novice designers to this question. At first, new designers tend to consider the problem from a media-centric perspective, adopting, as their primary design vocabulary, the patterns and structures supplied by media tools, making all other aspects of the design subordinate. Later in their careers, the same designers may find their emphasis has shifted toward explanation structures, strategic structures, or content structures as the primary focus, treating other considerations as secondary. The point here is that a designer can choose an entry point to the design sequence, depending on the set of design language terms or patterns felt to have the most beneficial design impact.

In the rest of this chapter I will show how placing priority on a particular design layer radiates, or ripples, constraints to the other layers of the design. I will use this sequence as a means of demonstrating (a) how design layers can be used as a framework for applying Alexander's concept of pattern languages to instructional design, and (b) how different priority sequences among the layers can lead to designs with distinctively different properties.

By doing this, I hope to illustrate how layers focus the designer's attention on different design sub-problems, creating the possibility of a more explicit foundation for the choice of a design order. In the process, I will produce an example of a pattern language for instructional designs created by designer priorities.

SEQUENCE OF LAYERS

The design sequence I will describe radiates from giving priority to the message layer. I have chosen to make this hard to understand layer the most important because the patterns of the message layer are among the most neglected in technology-based instructional designs.

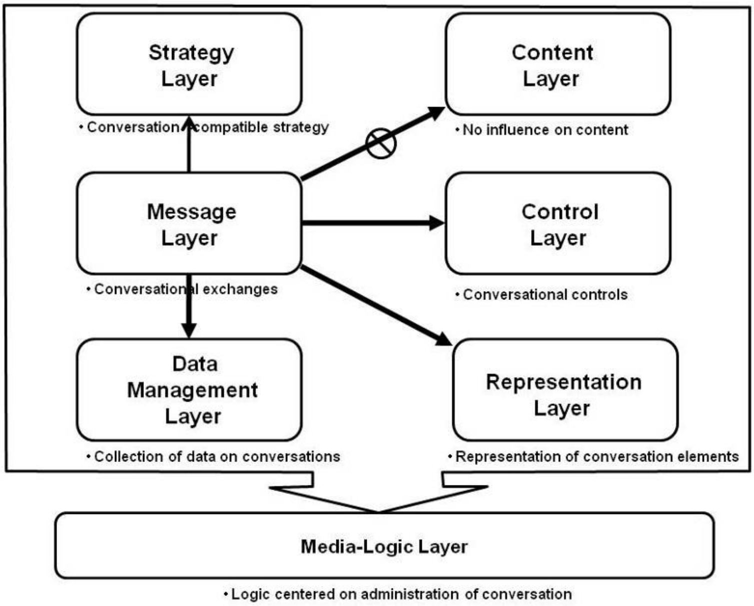

Figure 1. Influences radiating outward from the message layer when the conversational assumption is made the central commitment of the design.

Figure 1 illustrates the pattern of between-layer influences when the message layer and the conversational form assumption are made the central commitments of the design.

Selection of the message layer constitutes an answer to the question: 'What is it that I am designing?' For the purposes of this demonstration, the answer is: 'a conversation'. To support this choice, I will explain (a) my present commitment to instruction as a conversational act, and (b) the central role of the message layer in defining conversational structures.

INSTRUCTION AS CONVERSATION

Instruction can be described as a conversational activity as follows:

> Instruction is the intentional engagement in purposeful conversation of two or more agents capable of decision-making.

The key elements of this definition are:
- instruction is a specialized form of *conversation*
- engagement in the conversation is the *intentional* act of two or more agents or decision makers
- the conversation among these agents has a *purpose*.

Most would agree that instruction involves communication between two or more persons, but how can a person carry out a conversation with a technology package? And where is the conversation in self-instruction? To answer this requires a more clear definition of *conversation*. It is usual to think of a face-to-face verbal exchange as a form of conversation, but consider the following:

– What if the people are located in different rooms in a house, moving about, carrying out different tasks as the conversation takes place? Is it still a conversation if it is not face to face?
– What if people are talking on the phone (a medium)? Is it still a conversation?
– What if the exchange is carried out surreptitiously by texting while one of the people is in a meeting? And what if one of the participants can’t answer right away every time (time lapse)?
– What if the exchange takes place over the period of a week using notes posted on an office bulletin board (medium and time lapse)?
– What if the exchange were to take place with one person making an utterance that was three written pages long (a letter) or an hour of speaking (a lecture)? Can this be said to compress several turns of the conversation into one? And can the reply take place at a different time and place and still be part of a conversation?

As we imagine situations in which an exchange takes place over increasing spans of time and space, we see that the idea of conversation must be more flexible than we originally supposed. All the above examples, and others that could be devised, are classifiable as conversations because they share the following key defining characteristics:

– information is exchanged
– it is the intention of all agents to engage
– there is a willingness to listen and think before responding
– there is a shared purpose to the exchange.

These essentials describe many additional kinds of ‘conversation’ that are not the simple face-to-face kind the term commonly evokes. These include: conversations in which:

– tens, hundreds or thousands participate at once
– one of the turns is so long, and the numbers of people sufficiently large, that the responses of participants have to be delayed, have to be given in a more formal way (for instance as written responses), or may be impractical to give for every turn
– the time span is a period of years as scholars or problem solvers converse through conferences, journals and books
– turns are distributed across multiple media forms: person-to-person, speeches, letters, video clips, and messages through third parties
– participants may be separated by lifetimes, but, nonetheless, each writer or speaker responds to what an earlier one has written – sometimes only once (see, for example, Bloom, 1975).

It is the core of essential characteristics (information exchange, mutual intention, listening and thinking followed by responding, and shared purpose), and not the outward and visible parts of the communication, that define a conversation. For the purposes of this chapter, all patterns of human interaction that share these core characteristics are considered to be conversations, and it is assumed that the vast majority of these can be considered instruction.

Why chose conversation as a target metaphor for instruction? Because the conversation metaphor requires something that the others do not: that there will be two active agents during instruction who will listen to each other, interpret, reflect, and then, in one way or another, respond to each other. Too often when other metaphors are used, it is easy for the designer to create a one-way-only conversation in which the learner becomes a receptive, and mostly silent, participant. In many cases, we have come to accept as a standard of adequate instruction the presentation of information without relevant responding and engagement by the learner. Informing is adequate to some needs, but simply informing is insufficient in many learning situations – even when the instructional goal is 'knowledge' and not a skill. We cannot just inform people and assume that they will know how to use that information in daily situations where it is to be applied.

The definition of conversation above embraces many diverse instructional applications, including instruction

- over a distance
- using many different forms of media
- involving large groups
- that takes place over long periods of time in different settings
- involving many different role and initiative patterns
- based in technology
- delivered by human instructors
- that blends the human and technology.

Many more forms of instructional conversation can be described – for example, games. Games are a formal conversation with specialized rules for turn-taking and a restricted language of player actions (Salen & Zimmerman, 2004). Play in general can be described as a kind of conversation. Bruner (1983) observed that 'a game, in its way, is a little protoconversation' (p. 47). Rogoff (1990) describes guided practice, which generally includes conversation, as a means of instructing children to function within their culture and context. Even formal schooling can be seen in conversational terms. Tharp and Gallimore (1988) note that 'the task of schooling can be seen as one of creating and supporting instructional conversation among students, teachers, administrators, program developers, and researchers' (p. 111).

This also focuses attention on a broad range of methods, media, and settings that should appropriately be considered instructional. Any social experience can be viewed in terms of its instructional potential: camps, parades, concerts, public meetings, political campaigns, amusement and theme parks, displays on city streets, rallies, sports events, service projects, museums and zoos, online forums, clubs, ritual observances, ceremonies, public demonstrations, professional organizations, even visits to the dentist. Viewed as conversation, the list of potential instructional venues becomes astonishingly large.

IMPLICATIONS FOR DESIGN

If the thing being designed has an underlying conversational form, then certain dimensions of the instructional design become very important. First and foremost, the designer begins to think in terms of what the learner will be able to say or do (in their part of the conversation). This focuses the designer on the activities of the learner more than the activities of the teacher from the outset, which can be considered beneficial for several reasons. First, it is more likely that the learner will engage in performance, rather than receiving information. That is, the design will provide environments for the learner's performance activities first and foremost and treat the presentation of information as a supporting or scaffolding function for the performance. Secondly, it is more likely the designer's problem solving will focus more on the match between the activities during instruction and activity in everyday settings where the knowledge is used. It is more likely that the architectural and mechanical structures of the design will match performance supporting functions. This will result in designs where instructional functions will be seen as add-ons to a performance environment.

A designer of conversations also pushes certain kinds of decisions to a higher priority, as follows:

- *Scope of a single turn*: how long (in terms of time and substance) will the average turn be in a conversation? A turn may be very long (a lecture) or very short (a true conversation). A turn may focus on a single action or topic, or it may incorporate many open actions or topics.
- *Initiative and roles*: who is responsible for moving the conversation ahead? Does one agent control? Is the initiative negotiated? Does the learner have an assigned role? Does the initiative shift over time from one agent to another? When multiple learners take part, who has initiative and how does one exercise it?
- *Object of engagement*: is there some object or event that is used as the starting point of the conversation and around which the conversation will be centred? A question? An unsolved problem? An incident or event? An object?
- *High-level interaction patterns*: what general pattern will interactions during the conversation be expected to follow? Is there a beginning event, a middle part, and an ending event? What parts of the interaction will be structured by expected actions and what parts will consist of actions executed in an unplanned order? Will there be one or more judgment points where work to that point is assessed? Will there be gates between parts of the conversation through which the conversation must pass?
- *Moderation*: will there be a moderator or voice of authority during the interaction? Will there be a judge or criterion assessment? Will there be mutual judgment of participants? Will there be a referee?
- *Mediation*: what media channels will be used for expressions from the learner and to the learner? Will multiple media channels be used? (Media channels influence control and messaging, which in turn influence the kinds of thing a learner can say during an instructional conversation.)

- *Decision-making*: how will the instructional source exercise judgment or decision-making? How will responses to learner communications be processed before the instruction responds?
- *Negotiation*: which elements of the conversation are negotiable by the learner?
- *Engagement plan*: What provisions will there be for enlisting learner engagement and then maintaining it throughout the conversation? How is the learner kept in the conversation?

Answers to these questions provide the broad outlines of a design that the designer must bring into focus by means of decisions about structures and details. How many different forms can this conversation take?

THE MESSAGE LAYER OF INSTRUCTIONAL DESIGNS

The almost invisible message layer of an instructional design plays a pivotal role, especially when both live and technology-based designs are considered. The message layer of a design is related to the function of message formation. This process occurs in sequence before the selection or generation of sensory representations that can be broadcast to the learner across a ‘display’ surface. It occurs after certain high-level choices that combine abstractions (from the strategy layer) with strategic manipulations and supplementations (from the strategy layer). The message layer’s function is to translate the strategic intentions of the strategy layer (e.g. ‘conduct a quiz’, or ‘explain why this answer was incorrect’) into conversational terms that can be represented through one or more media channels (visual, audio, animation, etc.) in terms of multiple conversation turns. To do this, there must be a generation of a messaging intention to drive the representation function. This may involve the selection of a pre-fabricated message element (<You answered ‘B’; the correct answer was ‘A’ because it is the ventricle that pumps the blood out of the heart>) or construction of a message that is fabricated using rules operating on message primitives (<That is incorrect><The correct answer is ‘A’><ventricle pumps blood from heart into body>).

The angle brackets used in these examples indicate that message content has not been assigned a channel for expression. Therefore, it represents only an intention to represent, not a specific representation. This distinction is critical to the mapping function performed at the message layer, since a single message element (e.g. <that is incorrect>) may be mapped to multiple representations (e.g. >>buzzer sound<<; >>text turns red<<; >>text appears: ‘That’s incorrect’<<). Specific representations may be created by calling to the display surface pre-fabricated display elements (a graphic, an audio sound, an animation, etc.) or by generating display content from raw data using algorithms (e.g. a computer generates a graphic of the beating heart from a structured data file) or from ongoing computations of a model.

MESSAGE LAYER PATTERNS

Selecting the conversation as the dominant design figure (just as Alexander explained that we could select ‘city’ or ‘neighbourhood’ as a starting point) presupposes that the message layer is the occasion for defining multiple dominant patterns. Several general patterns of conversation commonly used instructionally can be described in terms of their variation across a number of parameters as follows:

- placement and sharing of initiative
- perceived roles of participants
- specific purpose
- number of participants
- location of participants
- time between turns
- length of turns
- shared standards of evidence and argumentation
- degree of civility or mutual regard
- presence of a mediator
- number of shared symbolic meanings
- medium of communication
- degree of willingness to participate
- motive for participation
- ulterior motives
- specific topic of conversation
- respect for turn-taking
- negotiability of conversation rules.

The constituent parts of a conversation include turns and initiative shifts (just as Alexander's building structures consist of spaces and barriers). The desirable qualities of instructional conversation can be structured in terms of several patterns, which are briefly described below.

Some patterns, like Alexander's, describe 'places'. The first set of patterns describes temporal places or passages in an instructional conversation:

- 1 INVITATION TO CONVERSE
- 2 TOPIC NEGOTIATION
- 3 ROLE NEGOTIATION
- 4 GOAL NEGOTIATION
- 5 INITIATION
- 6 RE-DIRECTION OF TOPIC
- 7 INITIATIVE SHIFT OR ROLE CHANGE
- 8 GOAL RE-NEGOTIATION
- 9 TERMINATION

The following patterns describe qualities that instructional conversations should incorporate:

- 10 RESPONSIVE
- 11 ADAPTIVE
- 12 REFLECTIVE
- 13 BRIEFEST POSSIBLE TURN
- 14 ENCOURAGING (COMPLIMENTARY, GENERATES HOPE)
- 15 SCAFFOLDING
- 16 MAINTAIN MOMENTUM/ENGAGEMENT
- 17 LEADS THE LEARNER

– 18 LED BY THE LEARNER
– 19 DEMANDS ACTIVE PARTICIPATION ON BOTH SIDES
– 20 ENJOYABLE
– 21 MAGIC/SURPRISE/AHA/DISCOVERY/REVELATION

Many additional patterns related to instructional conversation could be identified. Fox (1993) describes many patterns of instructional conversation in her analysis of tutoring sessions. Wenger (1987) describes the adaptive nature of instructional conversations and provides a model of dialogic communication. As this part of the chapter was written, it became even more apparent to the author how little attention in the instructional design literature is paid to the conversational nature of instruction and the principles for conducting instructional conversations.

INFLUENCES ON OTHER DESIGN LAYERS

As *Figure 1* shows, all the design layers except one – the content layer – are impacted by the commitment to the conversational pattern at the message layer. The sections that follow trace the major influences.

Influence in the content layer

The content layer of a design specifies the nature of the subject-matter structures and captures subject matter in a corresponding form so that it can be operated upon by other layers. Content may take many different forms, none of them being incompatible, or having adverse interaction, with the conversational assumption. For example, subject-matter can be handled as a set of ‘if…then’ rules in a manner described by Anderson *et al.* (1995), who employed rules as one of two subject-matter structures – the other being a semantic structure called the working memory element. Subject matter can, likewise, be treated strictly as a semantic net, which is the approach used by early researchers in intelligent tutoring. Wenger (1987) provides an extensive review of the range of knowledge representation mechanisms employed in intelligent tutoring. Of greatest importance to the present discussion is the realization that none of these subject-matter forms is incompatible with the structures of conversational exchange.

Influence in the strategy layer

The strategy layer of design consists of structures contrived to govern the social and physical setting of instruction and the nature and sequence of instructional events – both at the macro-level and the micro-level (Reigeluth & Schwartz, 1989). As the layer’s name suggests, the strategy consists of strategic arrangements of people, places, events, and things. It creates these arrangements in accordance with strategic goals that represent layer-scope attainments that are usually measured in terms of student action or knowledge achievements. Therefore, the important topic of instructional goals and their designed use lies within the purview of the strategy layer.

The strategy layer's goals for learner attainments are mapped to strategic actions of the instruction calculated to support learners in their movement toward those outcome goals. The strategic actions represent a kind of secondary goal, as if the strategy system were saying to itself, 'In order to help the learner reach the desired outcome, I will execute the following augmenting or supplementing actions.' The actions executed may include conducting a practice session and providing feedback following student responses, or providing an explanation of a particular relationship within the subject matter. Whatever the exact strategic action to be carried out, it will require many individual intentional acts to do so. The choice of strategic actions belongs to the strategy layer of design; the choice of individual intentional acts belongs to the message layer, and it is the separation of these functions and their assignment to different layers that allows the conversational assumption – or any other messaging assumption – to be made independently of high-level strategic goals.

There is considerable impact on the strategy layer of design from the conversational assumption. Strategic action choices must succeed in breaking the strategic choices down to the finest possible granularity so that the best match-up can be designed between the strategic actions and the turn-taking structure of a conversation. Moreover, the strategy actions must be expressed with a measurable end point so that the unpredictable conversational exchange can know when the strategic action intent has been satisfied. The major impact of the conversational assumption on the strategy is to break up easy-to-create massed expositions into the substance of piecemeal conversational turns. Instead of presenting extended explanations, explanations must be deconstructed into units of a smaller size that can be messaged as conversation turns in an indeterminate order.

This introduces new patterns related to strategy layer designs as follows:

- 22 STRATEGIC GOAL
- 23 STRATEGIC ACTION
- 24 SMALLEST POSSIBLE ACTION
- 25 ACTION TERMINATOR.

Influence in the control layer

The control layer consists of structures that can be manipulated by or arranged in different configurations by the learner to communicate the learner's intentions or messages back to the instruction. The control layer is the second lane of a two lane highway of communication between the learner and the instruction. The outbound lane consists of the joint efforts of the message and representation layers; the inbound lane consists of the provisions of the designer within the control layer.

Learners must be given several different kinds of controls to operate: controls over content choice, controls to express strategic choices, controls over representation styles and viewpoints, controls to access data on the learner's own performance and progress, and the ability to respond to action and knowledge challenges presented by the instruction. The most important controls given to the learner when the conversational assumption has been applied to a design are those that allow the learner to participate in the instruction. In live instruction, conventions of hand raising are generally used to allow the learner to signal the intention to communicate. An observant instructor can also notice facial expressions and body postures that indicate a learner's need or desire to send a message, or the need for a question from the instructor. In technology-based settings, few of these familiar cues can be interpreted, and so more explicit controls must be created. This aspect of a design poses special challenges to the designer, since complex or unfamiliar overt control systems can distract learner attention away from a learning activity. Other challenges include: (a) the lack of expressive power given the learner by technological interfaces, (b) the un-sequenced and shared-initiative character of conversational instruction, and (c) the variety of actions the learner may wish to make at different points in a conversation. At any point, the learner may have the option to request renegotiation of roles, goals, topics, initiative and timing or pace. The concept of an instructional conversation has little meaning without these options, and controls must be provided to give them to the learner.

Without the ability to carry on a full-featured instructional conversation, designers may use fallback positions that curtail certain elements of conversational choice by the learner, while still providing them with as many options as possible. This may be done by providing only certain conversational actions to the learner, or by creating structured languages to facilitate and channel the expression of complex messages from the learner to the instruction.

Creating a set of conversational controls also involves creating a representation of the history and threading of past conversations. A single student may have several conversations open with the instructor at one time: conversations about mechanics such as deadlines or work criteria, conversations about individual questions or sidebar issues, conversations to clarify main points in the subject matter, and conversations about possible extensions of class interest through research or writing. Controls must allow the learner to pick up a thread and pursue it through the next conversational turn, and the representation of all conversations must aid this.

Control-related patterns suggested by this discussion include the following:

- 26 CONTENT CHOICE
- 27 STRATEGY CHOICE
- 28 REPRESENTATION STYLE
- 29 REPRESENTATION VIEWPOINT
- 30 ABILITY TO RESPOND TO AN INQUIRY
- 31 ABILITY TO MAKE AN EXPRESSION
- 32 ABILITY TO INTERRUPT
- 33 ABILITY TO ASK
- 34 ABILITY TO PAUSE
- 35 ABILITY TO START A NEW THREAD
- 36 ABILITY TO NEGOTIATE INITIATIVE
- 37 ABILITY TO NEGOTIATE ROLES
- 38 AUTO-PILOT.

Influence in the representation layer

The representation layer supplies a display surface from which the learner can receive the combination of content, strategy, and the control choices. The display surface is the medium through which the conversation takes place. The greatest challenge of the display surface is to represent both the larger context and the exact substance of the conversation at the same time, and to do so economically and continuously.

Making a good instructional representation is both a technology and an art – the art of communicating large amounts of information economically (rather than in a way that merely looks polished or has a high production quality). Some representations accomplish this by their internal complexity and precise arrangement, as in the work of Edward Tufte (1990). Other representations accomplish this by many incremental steps like those used in the wordless assembly instructions that accompany plastic brick construction toys. Others use animations coupled with commentary. The range of precise, economical communication techniques for representation is enormous, but there are principles that can be embodied in any form of representation as patterns, as follows.

– 39 CONTRAST, SALIENCE
– 40 DEPOSIT A TRACE
– 41 PROPORTION, SYMMETRY
– 42 CHANGEABLE VIEWING POINT
– 43 INTEROPERABILITY, INNER LOGIC
– 44 ANOMALY, EXPECTATION FAILURE
– 45 NEW INFORMATION AT EACH RE-VISITATION.

Representations rely on symbols and systems of symbols. With increasing experience in control systems design, standards for more complex control sets are emerging. We can marvel at intuitive control sets for complex navigation such as those of Google Earth™ and at how quickly it is possible for novices to become proficient navigators of the representation as they lose themselves in the interface to look for and find their own homes.

– 46 UNIVERSAL SYMBOLS
– 47 MULTIPLE SCALES OF CONTEXT AND SUBSTANCE
– 48 ECONOMY OF EXPRESSION
– 49 INTUITIVE OPERATION
– 50 PROPORTION IN REPRESENTATION.

Finally, representations are derived from messaging intentions. There must be a correspondence in granularity between message structures and representation structures. This is a difficult and complex design challenge, as message elements can exist independently, but representations must integrate elements of information into larger units that are internally coherent and cohesive. The blending of individual elements required to do this is in some cases simple, but it can also be very challenging. For example, how do you represent the dynamic effect of an action by a learner on the representation of a beating heart? With emerging hardware and software technology this can be accomplished, but it requires the mapping of multiple message intentions into a unified representation. Such representations of complex systems that are responsive to learner actions on them are essential to conversational instruction. There is a complex grammar of message-representation mapping waiting to be revealed.

– 51 CONSTANTLY REFRESHED, UPDATED
– 52 DYNAMICALLY RESPONSIVE TO LEARNER ACTIONS.

Influence in the media-logic layer

The media-logic layer makes the designs of all of the other layers operate to create real experiences. The media-logic for a live instructor includes all of the skills and knowledge about instruction – all of the instructor's teaching habits, preferences, plans, and patterns. Supplying the rules for this layer of the design is so dependent on the skills of the instructor, that, when confronted with the need to supply the rules by technological means, the designer is often only able to create a simplistic mimicry of a few instructor-like actions.

At the same time, the computer as an instructional medium is poised to go beyond mimicry of the instructor to establish its own instructional metaphor, performing feats of teaching live instructors cannot. Serious simulations of many kinds already accomplish this. The realization (a) that computer-aided instruction is a new medium and (b) that there is a need to draw on the unique strengths of live instructors is creating a field of blended learning studies in which the media-logic of both will undergo improvement.

– 53 BLEND INSTRUCTOR AND TECHNOLOGY STRENGTHS

Conversational instruction makes special demands on the media-logic of both live and technology-based instruction. This is evidenced by the observation that some live instructors can conduct masterful class discussions, while others fail to do so. Prescribing the rules of conversational exchange to a computer that does not understand the subject matter and that has limited sensors to detect learner responses is one of the most difficult and long-standing problems of computer-based instruction (see Atkinson & Wilson, 1969). However, modelling techniques being applied to subject matter analysis and simulation development can presently carry on conversations with learners about modelled knowledge. Ontology systems, likewise, are improving the ability to frame learner questions and inquiries regarding the systematically organized content that models are capable of supplying. Models and ontological category systems for knowledge description also make it possible to track partial and fragmented communication of modelled knowledge, which matches the requirement of conversational systems to provide piecemeal, rather than massed, expositions and to detect partial knowledge mastery as it emerges. This makes possible systematic handling of the content of conversations from a media-logic point of view.

– 54 USE KNOWLEDGE MODELING
– 55 USE ONTOLOGY-BASED COMMUNICATION OF MODELED KNOWLEDGE

Computer programming language patterns have dominated the interactions possible in technology-based designs, because the structures provided by the programming tools are not designed with instructional structures in mind. This forces the user to modify strategic plans to fit what the tool structures make easy and affordable. Because conversational instruction places requirements on every layer of design, development tools must facilitate the creation of many software patterns. Some of those that are needed are directly related to the execution of the conversation cycle, especially patterns related to the message, representation, and control layers.

Media-logic patterns related to message construction:

- 56 CYCLE OF TURN-TAKING
- 57 CYCLE OF MESSAGE SELECTION
- 58 CYCLE OF MESSAGE CONSTRUCTION FROM GROSS PRIMITIVES
- 59 CYCLE OF MESSAGE CONSTRUCTION FROM FINE-GRAINED PRIMITIVES.

Media-logic patterns related to representation:

- 60 CYCLE OF REPRESENTATION SELECTION
- 61 CYCLE OF REPRESENTATION CONSTRUCTION FROM PRIMITIVES
- 62 CYCLE OF REPRESENTATION GENERATION FROM DATA
- 63 CYCLE OF DISPLAY MANAGEMENT.

Media-logic patterns related to controls:

- 64 CONVERSATIONAL CONTROLS.

Additional media-logic design patterns are related to the strategic and data management layers. Media-logic patterns related to the strategy layer include:

- 65 CYCLE OF STRATEGIC PLANNING
- 66 CYCLE OF GOAL SELECTION
- 67 CYCLE OF CONFLICT RESOLUTION AND INTERRUPTION AMONG LAYER FUNCTIONS.

Media-logic patterns related to the data management layer:

- 68 CYCLE OF ACCUMULATION
- 69 CYCLE OF ANALYSIS AND INTERPRETATION
- 70 CYCLE OF COMMUNICATION TO OTHER FUNCTIONS
- 71 CYCLE OF COMMUNICATION TO THE LEARNER.

Influence in the data management layer

The function of the data management layer is to gather, summarize, analyse, interpret, and report the data resulting from learner interactions during instruction. Huge amounts of data are generated by such events. But data collection and data analysis must be at the same level of granularity as other functions: strategy, messaging, representation, and control. Moreover, there must be sufficient data to detect both knowledge and affect states in the learner. The value of affective state data – which live tutors collect and interpret without even being aware of it – is especially high in technology-based instruction. Nuance in instructional technique, which is the essence of adaptive instruction, is most heavily influenced by cues about affective states, rather than knowledge level, because of the need to maintain the engagement of both the instructor and the learner in conversational instruction. If the instructional conversation is perceived by the learner to require more effort than it is worth, then the learner can easily choose to terminate the conversation, even if there is no formal notice from the learner that this has happened. This accounts for learners' in-class lack of interest, lack of enthusiasm for schooling, merely compliant behaviour and truancy.

Data shared with all other layers allow them to carry out their individual decision-making functions. Sufficient data should also be shared with learners to allow them to participate in instructional decisions within their initiative. Finally, when the learner's own resources are not up to the task of making instructional decisions, data-keeping must allow the instruction to make suggestions, both solicited and, in some cases, unsolicited.

– 72 KEEP RECORDS OF CONVERSATIONS
– 73 DATA GRANULARITY THAT MATCHES STRATEGY, MESSAGE, CONTROL, AND REPRESENTATION NEEDS
– 74 DATA TO DETECT KNOWLEDGE STATE
– 75 DATA TO DETECT AFFECTIVE STATE
– 76 SHARE SUFFICIENT DATA TO SUPPORT LEARNER DECISION MAKING
– 77 ADVISE WHEN ASKED OR WHEN JUDGMENT SUGGESTS.

CONCLUSION

The purpose of this chapter has been to demonstrate that instructional design layer theory, as described by Gibbons and Rogers, supplies a framework for identifying patterns that can be used in instructional designs for both live and technology-based instruction. Seven design layers were named and described that define design sub-problems, which must be solved in the process of creating a complete instructional design. The layers represent major functions carried out during instruction, including: the formation of messages and their translation into representations to the learner, the definition of content parcels and their supplementation by strategic plans, the structuring of learner-initiated communications, and the execution of instructional logic and data gathering on learner interactions.

As a beginning point for this demonstration, a particular layer – the message layer – was selected, and a particular message structuring pattern – the conversation – was chosen to provide a beginning point for defining patterns within the message layer and all of the other design layers as well. One of the main goals of the chapter was to show that design layers suggest fruitful areas for pattern definition that correspond with major subdivisions of instructional functions.

A second goal of the chapter was to show that patterns allow both live and technology-based instructional designs to have more of the 'aliveness' quality that Alexander worked so hard to define and exemplify. By choosing the conversational metaphor as a beginning point for pattern definition, this chapter has shown that a more personal and human quality can be designed into technology-based instruction, radiating from the conversational core assumption and influencing every other aspect of the design.

One of the criticisms of technology-based instruction, and much live instruction, is that it lacks the human qualities that stimulate engagement in learning through personal treatment and responsiveness to the individual. This chapter has attempted to show that it is not necessarily the case that the use of technology in instruction must foreclose this human quality. However, this quality must be deliberately designed into our instructional artifacts, and the patterns suggested by the framework of design layers can help to reclaim the personal quality of systematically designed instruction.

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