Open teaching: The key to sustainable and effective open education

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WHY DO WE NEED LEARNING TECHNOLOGIES?

If the current plans for education are fulfilled, then the 21st century will become the century in which we transform the quality and reach of education. There are some impressive ambitions to be found in educational strategy documents, both national and international. The United States has the "No Child Left Behind" campaign. The United Kingdom has "Every Child Matters" as the vision for a national strategy to join up all the public sector agencies responsible for the well-being and education of children. The European Union's Lisbon agreement requires every country to build its workforce skills to a much higher level. The United Nations' millennium goal for education is one that every nation inherits, and it provides the ultimate challenge for education: to achieve universal primary education by 2015.

We are now several years into the millennium, but scarcely nearer to achieving this goal. It would require a teaching community capable of building its expertise and multiplying its numbers at a fantastic growth rate, even within the original fifteen years. Similarly, the worldwide demand for higher education continues to grow. Estimates from the Observatory on Borderless Higher Education (OBHE) suggest that worldwide HE places will rise to 125 million in 2020; demand

[1] Chapter in *Opening Up Education: The Collective Advancement of Education through Open Technology, Open Content, and Open Knowledge*, Toru Iiyoshi and M. S. Vijay Kumar (eds), MIT Press, 2008.

for international education places are predicted to be 5.8 million by 2020; and the age participation rate is 40% – 50% in the "north," but less than 5% in many developing and emerging economies (2003).

Wherever we look, around the globe or in our own backyards, we can see that more and better education is needed. But the scale of the problem cannot be tackled through our traditional technologies for teaching. When you measure student numbers in billions, staff-student ratios of 1:30 make no impact at all. So the problem of scale is challenging.

Traditional education fails millions of students across even the highly developed countries: an average of 6.5% of fifteen-year-olds fail to achieve Level 1 literacy (OECD-CERI, 2006). We have not yet discovered how to achieve more effective education for those excluded or disaffected by our current system. The ambition to bring education to the world is laudable, but we have only a partially successful system to offer. The problem of quality is just as challenging as the problem of scale.

So we have to ask: how could such a transformation be contemplated without recourse to a technological solution?

Technology is never the whole solution. The recent history of technology in education always tells us that however good it is, it achieves little without the complementary human and organizational changes needed, and these are always more difficult. Using technology to improve education is not rocket science. It's much, much harder than that. Change in education is not a matter of a small number of extremely highly educated people moving a collection of obedient atoms from one place to another. It is about large numbers of partially trained people moving minds,

millions of them. That is why we look to interactive communications technologies for help. They are capable of emulating the best-quality teaching, but on a larger scale and with wider reach.

The focus of this chapter is to work out how to achieve that. The argument is that we need technology to achieve the educational reform we dream of, but that we have to do it through the teaching community. An essential part of the open education movement will be "open teaching." The teaching community will need learning-design tools and environments that will enable them to develop the new pedagogies afforded by digital technologies, use the open education resources becoming available, and achieve high quality teaching on the large scale.

WHAT IS THE EVIDENCE THAT LEARNING TECHNOLOGIES CAN HELP?

The two educational challenges to technology posed in the previous section are the problem of quality—how do we ensure the quality of the learning experience and learning outcomes? —and the problem of scale—how do we provide for all the education needed?

We know that technology offers the greater flexibility of education provision that enables more people to take part. The UK Open University (OU) has over 200,000 students in over 70 countries, studying through a blend of online and printed materials, and online and face-to-face tutorials, provided locally. And technology-based methods work just as well for school-level study where, for example, online courses enabled learners at work to achieve the school qualifications they missed; a "virtual school'" for children excluded for behavioural reasons gave them a

combination of remote access and one-to-one teaching that brought 90% of them back into mainstream study or work-based learning (DfES, 2005). The feasibility and value of this flexible provision has been demonstrated in many such cases. Success depends upon the quality of learner support, and flexibility fails when this is not provided. The success of the OU model, for example, was demonstrated when the University came top of all UK universities in the survey of "quality of student support." Distance learning need not mean isolation. With these models of successful flexible online provision, we can see that it becomes possible to extend education well beyond the confines of the physical place to a much wider group studying online and attending only occasionally.

We only meet the challenge of scale, however, if we can make this kind of provision at a lower unit cost as numbers rise. There is a myth abroad in the minds of policymakers that online provision is cheap—that the same material can be provided to much larger student numbers than in a physical environment, and therefore, with much lower variable costs, educational provision can be expanded without a commensurate increase in cost. The cost/quality relation is not so simple, however. The UK OU has been more successful than any other distance-learning university in terms of retention, attainment, and expansion because it provides excellent learner support, but has not significantly reduced its unit costs. In general, the bill for the introduction of ICT into education has been high (currently close to £1bn per year if both government and institution costs are included across all education sectors in the UK), so the unit cost of education is increasing. The return is hard to measure, but is certainly not sufficient to make a dramatic difference in overall attainment measures. That should not surprise us because the major investment in schools, for example, began only five years ago and took time to put in place. The same is true in the

commercial world; it can take many years to show a profit from a major IT-based reconfiguration of a company. As we learned in the latter decades of the 20th century, "computer hardware's contribution to overall economic growth is limited . . . To get a big pick-up, the return earned by computer hardware and software must surge in coming years" (Sichel, 1997).

Transformational change cannot happen overnight. However, unless every education institution is focused on how to use technology to improve the value of education—a "benefits-oriented cost model"—costs will continue to rise without the return (Laurillard, 2006a). The model shows that technology only achieves improved value for money when an institution plans in *both* improved quality and improved scale. Critical to this approach is ensuring that the institution exploits the reuse and sharing of open education content and design tools, as we see below. There are few such examples on either side of the Atlantic, and they tend to be small-scale. But when the management of innovation focuses on both quality and scale, as in the Pew programme on learning technology, then the twin benefits are achievable (Twigg, 2002; Twigg, 2003). We return to the management issue later.

There is one sense in which education can expect new technology to improve the cost equation. As the ICT infrastructure in a country gradually expands for business and domestic reasons, its education systems can exploit this without always paying for it. Home access to computers and the Internet is already over 75% for schoolchildren in the UK, and HE students studying online typically provide their own access at home and sometimes at work. This amounts to massive private investment in digital technology for education and means that it becomes feasible for public funding to provide access for the relatively small tail of the population who cannot provide for themselves. So the access problem is not insoluble; in time it

lessens. The greatest problem is always to ensure that our human and organizational systems are capable of the change they need to embrace.

We need technology to address the scale of the educational challenges we face within developed countries, to raise the level of skill and understanding within the workforce needed for a knowledge society, and to achieve adequate levels of primary through higher education across the developing world. We have seen many case examples of improved quality through technology: teaching programs that motivate learners, offer higher levels of engagement and practice with difficult concepts and skills, and provide personalized and adaptive feedback to assist mastery learning (Becta, 2006). Such programs can be used to extend what an individual teacher can offer, making it possible to improve quality without expanding the number of teachers at the same rate as the number of learners (affordable improvements in quality are possible, for example, if we simultaneously achieve improvements in scale).

We know that technology can offer radically more flexible ways of learning, enabling people who otherwise would not be able to access education to do so. And we know that through careful planning of online communities and information systems, it is possible to achieve high quality student support for remote students. We have the technology. We do not yet have the quality of change management within our education systems that would enable us to exploit it.

If we are seriously to address our ambitions for education we need to understand how to exploit learning technologies and the idea of open education to the limit.

WHY HAS THERE BEEN SO LITTLE INNOVATION AND NO CHANGE OF MODEL?

Digital technology has captured the imagination of many and enjoys constant invention of new forms of exploitation in business, domestic, and leisure contexts, resulting in radical changes in some cases. In the education systems of developed economies, digital technology has been available for experimentation for many decades and has now become ubiquitous in many educational contexts. It has not yet achieved significant improvement in the quality and scale of education, however, nor any radical change in the model of education.

Why so little progress? Here are five plausible explanations:

1. The education system is a complex system of powerful drivers—assessment, curriculum, inspection/quality requirements, funding flows, promotion criteria—none of which have changed significantly in recognition of what technology offers. These drivers determine the ways in which teachers and learners orient their energies and are judged by others. Unless the drivers of the education system change, the behaviour of its members will not change.
2. Technological change is very rapid. We have seen the digital equivalent of many key technologies for education in the space of half a century—the equivalent of writing, the pamphlet, the book, publishing, photography, film, broadcasting, the telephone, the printing press, the postal system. While it took many centuries to develop our education systems through these old technologies, we have not yet had time to make the radical changes afforded by digital technologies (Laurillard, 2005).

3. The education system is run by leaders who are not comfortable with either the detail or the implications of the technology potential, and those who are, are not powerful enough within the system. There has been radical change in some institutions, demonstrating the importance of leadership. Institution leaders need the direction to be set at national level, and they need more support for the changes they must direct within their own institutions (DfES, 2005).
4. Education is essentially a political activity and a national enterprise, embodying the moral values of a country, so it does not easily become commercialized or globalised, and therefore avoids being subject to the innovation that market forces encourage (Readings, 1996).
5. Education systems change slowly because they tend to be hierarchical command-control systems, rather than devolved-power adaptive systems. Teachers and lecturers are given neither the power nor the means to improve the nature and quality of the teaching-learning process through technology (Elton, 1999).

On that analysis, our education systems are doomed to irrelevance and inefficiency, unable to even begin to meet the challenges of the 21st century, because they cannot rethink themselves fast enough.

One possible future is that the commercial world will eventually understand the nature of education as a business. Most commercial online education enterprises have so far failed (Garrett & MacLean, 2004), primarily because they have failed to understand the nature of education: that they are not selling a product, but a long-term personal service. The point is well understood by the most successful recent example, the University of Phoenix, which has used technology to tackle only reach, not scale.

In 2003 its 72,000 students totaled a fraction of the UK Open University enrollments of 200,000. To minimize attrition, it maintains small classes for its online version (Symonds, 2003). This approach remains successful by maintaining the business models of traditional universities, not by developing new forms of education as the OU did.

The failure of private enterprise to reconfigure education through technology demonstrates how important it is to be clear about the fundamental and unchanging values of education. These constitute the fulcrum about which we move the world of education to a system fit for the 21st century. We make radical change through technology best if we understand what must remain constant.

Education is not like a normal commercial enterprise because the transaction between the individual and the provider is a very personal contract. There are no customers, and they are certainly not always right. It is a delicate relationship of mutual trust and nurturing, more akin to parenthood than commerce; it is selling the potential, and only the potential, for people to change and develop, more akin to a gym than a supermarket. Learners enter into an unequal relationship with the provider that helps them develop as individuals in ways they cannot yet specify, judges the extent to which they have developed, and accredits them on its terms, not theirs. The contract gives them no redress if they do not get what they hoped for—if they fail it is their loss. To achieve this, the education system has to be capable of great trust and authority. It is essentially unequal, with the formal system taking the responsibility of providing access to the key ideas of the culture, which enable individuals to take their place as citizens, and to use their understanding of the world and society in their community and in their work. This is true for every level of education. And formal

education, in this contractual sense, is fundamentally different from informal education.

Similarly, the contract between the state and the education system is one of trust: that the education system will prepare the nation's citizens for what the nation needs. The state will pay for formal education, or subsidise it, while it appears to succeed in doing that. In 1997, the UK's National Committee of Inquiry into Higher Education made the definitive statement that "the aim of higher education is to enable society to make progress through an understanding of itself and its world; in short, to sustain a learning society" (NCIHE, 1997).

Technology may change much about education, but the nature of its contract with individuals and the state is fundamental. Perhaps that will also change, eventually, but we are considering here what education "as we know it" could become.

HOW DO WE MOVE FORWARD FASTER?

If we accept that the future of education would benefit from appropriate exploitation of digital technologies, then we have to consider how our education systems are to make the shift to a trajectory of progressive, holistic innovation, a step change from the fragmented incremental innovation we have at present.

From the previous analysis it is clear that we have to address the powerful drivers that define education. Educational leaders have a responsibility to drive a strategic approach to the reform of education that fully exploits what technology can offer. This top-down, holistic approach to technology-based change has not yet been undertaken in any country. It would require a government to embed in every part of its educational strategic thinking the consideration of what digital technologies could

contribute to what they are trying to achieve, and to coordinate those efforts across all the sectors of education. In an ideal educational system, an individual learner would move through seamlessly from primary to secondary to further and higher education and would be able, as a lifelong learner, to move between work-based, home-based, and formal learning as they wished. Digital technologies have the capacity to support the learner through the information and guidance needed in making those critical transitions. In practice, in many countries, the responsibility for the different educational sectors rests with different parts of government, making top-down coordination of the learner's experience almost impossible.

The UK has the first government e-learning strategy to embrace the whole education system in a drive to improve the use of technology (DfES, 2005). However, responsibility for its implementation has been handed to external public sector agencies, divorcing it from mainstream educational policy. While educational reform is driven top-down, exploitation of technology in service of reform should be closely linked to it, remodeling educational drivers as appropriate. A good example is evaluation/assessment of students, one of the most important "drivers" of the behaviour of both teachers and learners in all parts of education Twenty-first-century students equip themselves with valuable skills for the acquisition and processing of information and ideas, and assessment of their learning could be carried out in very different ways from the suboptimal examinations and multiple-choice-question techniques of previous centuries that still dominate. Reform could be radical and highly productive if it were led in part by the new opportunities offered by technology.

Large-scale reform of education is risky for democratic governments; when linked to large-scale use of technology, the risk escalates. So why risk the top-down

approach? The education systems in many countries have already effected very large-scale implementation of technology by providing targeted funding for hardware, software, and networking. In the UK, for example, this has not been run as a top-down project but has devolved the funding to local decision-makers, enabling local ownership of the acquisition and innovation that follows. This marks a success for top-down government intervention, essentially by enabling bottom-up change through targeted funding. The value of the approach is that it is low-risk—there is now widespread access and use, and no prospect of a big technology failure, because it is all so fragmented. That is also the problem. It is fragmented and non-strategic. Such a change process cannot achieve radical system reform because the top-down drivers of the educational system remain unaffected. While technology is still just an interesting sideshow, unrelated to the strategic drivers of curriculum development, assessment, qualifications, accreditation, inspection, teacher pay, and promotion, it cannot deliver radical change.

Suppose we make the assumption that governments will not easily achieve holistic, system-wide, technology-aware reform of education? It could still be possible to work towards radical reform through the open education approach. Open education has the great advantage that it can support directly the people within the system whose practice will be changed most by the proper integration of technology: teachers and lecturers. It therefore has the potential to mitigate the characteristics of education that constrain its ability to innovate.

Many teachers and lecturers have embraced technology to assist their own pedagogic ambitions for their students, but most have not. The powerful drivers of their behaviour as professionals do not drive them towards use of technology—assessment methods, inspection criteria, promotion criteria, and funding flows

continue to be directed towards traditional teaching—and yet these are the determinants of classroom practice. Inevitably, with little system support around them, any teaching innovator will expend much energy in working against the grain of the existing system. To counter these endemic constraints on innovation, we need education leaders to create the "learning organizations" that are "capable of adaptive learning" (Laurillard, 2002), in which professionals can work together to experiment and build a better system. But it cannot all be "top-down." We also have to prepare for what this means for teachers and lecturers, and how they could drive system change "bottom-up."

The idea of a learning system capable of adapting itself to new environmental conditions is applicable also to the teaching community itself. Our knowledge and understanding of "technology-enhanced learning" will accelerate faster in a teaching community that acts like a learning system—one that makes knowledge of *what it takes to learn* explicit, adapts it, tests it, refines practice, reflects, rearticulates, and shares that new knowledge. Teaching must become problematised, innovative and professional, taking research as its model. If lecturers were to conduct the process of teaching as rigorously as they conduct their research, then they would expect 1) support for some personal development in how to teach, 2) the means to build on the work of others to design their approach, 3) the means to experiment and reflect on what the results imply for their design and their understanding, and 4) the means to articulate and disseminate their contribution. Those four characteristics together define the essentials of what we might call "open teaching"—what James Dalziel has called "open source teaching"—(such as an environment in which "educators can freely and openly share best practice teaching" (Dalziel, 2005). This communitarian approach reflects the ideals of the research community in general, and the scholarship

of teaching in particular (Kreber & Cranton, 2000). It would enable the teaching community, throughout the education system, to learn how to adapt to the new challenges for education and to exploit technology in the process.

The idea of "open education" makes this possible. "Open technology" means that the documentation of our findings transfers as easily across departments and institutions as paper does. "Open content" means we can adopt and adapt each others' technology-based teaching innovations as easily as we can build on research findings. "Open knowledge" means we have the means to capture and disseminate our pedagogic ideas as easily as we can write and publish papers.

The key to change and progress within the education sector is to use open education to create the innovative forces throughout the whole system that will help to drive it forward. Education leaders have not used the opportunity of digital technologies to transform education top-down—could it now begin to happen bottom-up?

WHAT WILL IT LOOK LIKE?

Part of the point of a bottom-up approach to reform is that we cannot know exactly where it will go. It will be up to all of us to shape it. That would make it a much more dynamic system, where learning is a joy and teaching is fun because learners are enjoying the struggle it undoubtedly is to grapple with difficult ideas and high-level skills.

The promise of fun lies in the creative opportunities provided by open education tools and resources, which offer a kind of toy-box for teachers. The digital world frequently achieves an epidemic of interest because the technology being

offered provides opportunities for individuals to either communicate or be creative, or both—email, PowerPoint, online games, blogs, wikis, social software . . . education could do the same by providing the tools and resources for teachers to make their own pedagogy.

At the Open University a few years ago, we attempted to build the means for lecturers to capture and disseminate their best pedagogical ideas. The research project SoURCE (Software, Use, Reuse and Customisation in Education) identified proven interactive learning products, turned them into a generic form, and then transferred them to a different department. For example, a learning design on eliciting and comparing learners' personal constructs of historic paintings was adapted to the generic form of an "elicitation engine," and then customized to chemical reactions, enabling chemistry students to generate and compare their constructs of different chemicals. In both cases it was a valuable initiation into thinking about new ideas. The project took as its basic methodology the following stages:

Stage 1: Identify a learning design for a specific objective which has been proven as valuable for students (such as an art history program).

Stage 2: Adapt this learning design to its generic form (replace the links to files showing paintings with requests to the teacher for links to content files; replace the links to expert definitions and their links to the exemplars with requests to the teacher to insert such links; leave all the interactive pedagogic functionality that directs students to select three items and think of how two are similar and different from the other, etc.).

Stage 3: Customise this form to a new context with a similar objective, inserting new content as appropriate (insert the links to video clips of chemical explosions; insert the links to expert descriptors and associated chemicals).

Stage 4: Implement and test the new combination in its new context.

The whole process was evaluated, and generated as final products (a) two interactive learning designs for similar objectives, but applied in different content areas; (b) two sets of content objects; and (c) one generic learning design. The project concluded that the process was feasible but that significant effort was required to ensure dissemination and reuse of the learning activities, which could only work in a system that supported "the exchange of learning objects" (Laurillard & McAndrew, 2003).

Learning object repositories are now being established in the form of both content "assets," (such as digital libraries of photos, sound archives, video footage, etc.) and in the form of learning activities that present and test content (such as a heart simulation or a game to balance equations). The former are usually managed by libraries, whereas the latter are found in academic repositories such as MERLOT (http://www.merlot.org), OpenLearn (http://www.openlearn.open.ac.uk), and JORUM (http://www.jorum.ac.uk). These are good initial approaches, but do not constitute the means by which we can capture and disseminate pedagogic innovation for others to build on. The pedagogic basis of the art history project was attractive to the chemists, but without the extraction of the generic form they could not use it. Learning objects typically bind together the pedagogic form and the specific content. Learning object repositories are beginning to provide valuable digital assets for insertion into generic pedagogic forms, but we do not yet have many examples of the latter.

If the teaching community could cultivate an "open teaching" approach, making use of the opportunities digital technologies offer, then we would have the means to build and develop this kind of knowledge: a collective understanding of what kinds of pedagogies, or learning designs, are capable of achieving a specific learning outcome. As an illustration, Figure [Laurillard chapter#.]1 shows an example of how a specific simple learning design can be generalized to capture the pedagogic design, and enable this to migrate across discipline areas.

FIGURE [Laurillard chapter#.]***1 ABOUT HERE***

The process will not work for all types of learning patterns, but many pedagogic forms are capable of being adapted in this way (the "lecture" is one obvious example from traditional teaching methods). As the teaching community explores the new pedagogies available through digital technologies, we will need tools capable of assisting this process and, happily, the technology can provide them (Laurillard, 2006b).

A new research project is attempting to build the kind of learning design tools that would enable lecturers to capture and disseminate their proven pedagogical innovations. In the UK, the JISC (Joint Information Systems Committee for higher and further education) has launched a "Design for Learning" programme, in which projects are building exemplars and demonstrators to test the idea that it is feasible for lecturers to take more control of pedagogic design and development, and to exchange their best ideas, so that they can build on each others' work as they do in research. One of the projects, the "User-oriented planner for learning activity design," is building pedagogic analysis, advice, and guidance around an existing learning activity authoring system (LAMS—the Learning Activity Management System; see www.lamscommunity.org). The system supports lecturers in designing and building

good interactive learning designs, linking to existing learning patterns and learning objects for them to build on, and eliciting an experimental approach to the design of learning activities. It is flexible enough to cover sequences of activities that enable their students to communicate, collaborate, and consult existing materials and learning objects.

The benefit of using LAMS is that it provides the means to capture and disseminate a lecturer's proven pedagogic design (www.wle.org.uk/d4l). The approach would therefore contribute to all four conditions of building a more communitarian approach to teaching: 1) some personal development in how to teach, through advice and guidance; 2) the means to build on the work of others through links to existing learning designs, learning objects, and content assets; 3) the means to experiment and reflect on what the results imply for their design and their understanding, through a simple learning activity authoring system; and 4) the means to articulate and disseminate their contribution, through the pedagogic design captured and customisable in the form of a LAMS activity, and disseminated through the LAMS community website. The project is carrying out a needs analysis with faculty from different disciplines, designing and testing a succession of prototypes of how the tool might work to assist them. We have a long way to go, but if we can make this kind of design support tool work for faculty, we would then have a robust and sustainable means to accelerate wider engagement with the scholarship of teaching. It would complete the vision of open education with a new kind of activity: open teaching.

CONCLUSIONS

To summarise, the micro factors that will do most to accelerate the growth of this new kind of teaching community are both "bottom-up" and "top-down":

- professional training for teachers at all levels of education, including HE, to acknowledge that it is needed for teaching as much as for research;
- support for strategic leadership in e-learning at institutional and national levels of education, to ensure a "learning institution" environment for innovators;
- R&D on technology-enhanced learning, carried out through partnerships between research labs, publishers, software houses, and teachers, to build the tools, resources, and learning design environments necessary for open education; and
- a common systems architecture for learning and teaching, and common open standards for digital tools and resources, to ensure exchange across institutions and disciplines.

Technology is innovative, complex, and expensive, but can deliver our highest ambitions for education. If it does not achieve improved quality of the learning experience, at least in terms of the level of outcome, and does not operate at scale, in terms of improved reach to those currently unable or unwilling to participate, then we have failed to exploit its potential. Reaching out to new learners or reengaging learners throughout life exploits the large-scale capability of digital technologies, and needs top-down, strategic leadership to make the most of what they offer. On the other hand, the quality of the learning experience is highly dependent on the teacher and how the learning process is conducted. That has been the focus of this chapter—to use technology to transform education bottom-up, through enabling the teaching

community to act in the most scholarly and professional way possible. But even this is only feasible if education leaders act to provide the infrastructure and reform education drivers to promote the changes that open education offers.

How will we know when we have succeeded in transforming education through the use of technology to build "open education"? What are the key indicators?

For really difficult questions about new technology, it is often valuable to go back to old technology and ask the same question: what would have been the right indicators by which to judge the major educational innovations of earlier times? The invention of the printing press was important because it gave more people access to knowledge; perhaps the great political revolutions were a natural consequence, so the right indicator would be "does it trigger change in the structure of society?". Universal schooling was certainly designed to create a different structure in society. But what is the right indicator for its success? More people with a sense of responsibility for what they know? Yes, there has certainly been a shift from an agricultural workforce to the knowledge workforce we have now. The educational innovations of old provided both a different quality of engagement with ideas (not just sitting at the foot of the master, but having direct access to the ideas), and a wider reach (through universal access). What will happen when we have a new level of engagement, offered by user-controlled interactive programs, together with even wider access through digital presence: a worldwide sustainable learning society, capable of understanding itself and its world? Educational aims should be ambitious, and should set out to challenge the technology that is so often in the driving seat of change. The idea of open education is to wrest the reins from technology and harness it to a higher cause.

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Figure 1: Generalisation and migration of a learning pattern.

(a) A specific learning pattern is designed for a topic-specific learning outcome, with topic-specific details in bold.

(b) This is generalized to a generic form for this learning pattern by generalizing the topic-specific detail as a place-marker; this is a form that can migrate across subject disciplines, but still carries its pedagogic design.

(c) The generic form is then customized to a new topic by inserting it in the place-marker for topic-specific detail, creating a new specific learning pattern.