Achieving educational soundness in the digital age

Susan Atkins
Manager, Educational Design and Quality Assurance
The Le@rning Federation

The digital revolution is affecting many aspects of life from shopping, to share trading, to gameplay, to communication. The transformations are visible in a number of sectors; there are changes to the way we work, learn and play. The digital revolution offers new opportunities for education – a chance to improve learning outcomes and ensure that today's students are equipped with the skills and knowledge needed to live in the knowledge age. However, maximising these opportunities requires investment, innovative thinking and experimentation.

The Le@rning Federation, a five-year development initiative established in 2001, is building a rich bank of high quality online content tailored for the purposes and needs of Australasian schools. The Le@rning Federation is managed in a joint venture of Curriculum Corporation and *education.au limited* to address the educational challenge of developing materials that complement and enhance learning experiences for students. The Le@rning Federation's experience in developing online curriculum materials is one part of and one step towards achieving maximum success in the knowledge age.

This paper explores the challenges of developing digital educational materials for the Australian and New Zealand schools sector, and provides useful information derived from hands-on experience for others contemplating the task.

The key challenges

The brief of the Le@rning Federation is to work on behalf of and with all education systems in Australia and New Zealand to develop online learning materials for students. Let's consider the elements of this brief and some of the decisions that have been made in the light of the brief.

High quality learning resources

The challenge is to design and develop rich and integrated learning experiences. The Initiative has adopted a 'learning object' approach. The learning objects may be a single file (html document, flash interactive, video, audio) or a composite providing a learning context.

The objects should contribute to the learning of the user. They are not meant to be assessment experiences or revision experiences or drill and practice experiences. They are meant to contribute to the understanding of concepts and processes and the development of skills. This does not mean that assessment, revision or drill and practice cannot be exhibited through interaction with the learning objects but this is not the primary focus. At the most granular level a learning object must have content integrity and able to be used independently for learning. They must also be developed with potential repurposing and recontextualisation in mind, so that they may be combined into learning sequences developed by a teacher within a specific learning environment for specific learning needs.

Curriculum requirements

The curriculum requirements of nine curriculum jurisdictions are to be considered: each of the Australian states and territories and New Zealand. While there are substantial similarities across the curriculum frameworks in the conceptual development of knowledge and skills, there are differences and these must be taken into account. The Le@rning Federation has set in place processes to ensure that the materials are educationally sound and suitable for all jurisdictions.

Both Australia and New Zealand have diverse student populations: geographically, culturally, cognitively, motivationally, linguistically and diverse in many other ways. The materials, together, must meet the needs of a range of user groups such as girls and boys in large metropolitan cities, students in small country towns, those living in remote indigenous communities, students who have arrived in the country with little formal education, those who have a physical disability, those in distance education settings, and gifted and talented students. Of course not every individual learning object will cover all possible user groups but together they must.

Access

The materials need to be able to be delivered online. This does not mean that all students will interact with the materials online; some will work with them downloaded onto individual computers, some will work from a school network, others from a CD ROM or some via learning management systems. But in all instances the materials will be multimedia.

Access is required across a range of situations from dial-up connections to big pipe broadband connections and this, inevitably, has implications for the overall form and size of each of the learning objects. The learning purpose, scope and intent of the learning activity in relation to the media selected to express and realise the content, such as the amount of audio and video, need to be considered carefully and used judiciously to contribute to and enhance the learning experiences of the students.

Optimising learning

The Le@rning Federation's brief is to exploit the media to augment the learning experiences for students, not to replace the teacher or the learning that can occur by students investigating in the science laboratory, or reading a book, or investigating concrete materials.

The materials are to be digital and must use the digital medium to optimise the learning. It is expensive developing materials in this new environment so there is little point in making learning objects about concepts that can be presented more effectively through other means; for example, hands-on classroom practical activity. The digital environment has much to offer: multiple pathways and starting points; instant feedback and scaffolding to aid learning; the combination of audio, video, graphics, animation and text; the possibility of conducting experiments that can't be reproduced in classrooms; and the facility to cache research and other information into a readily retrievable form.

By exploiting these attributes of the medium, students will have the opportunity to experience the presentation of content in different ways and, at the same time, be supported in extending their range of learning modes.

The Le@rning Federation approach to the key challenges

Working on the assumption that teachers need the flexibility to shape and organise classroom resources for particular groups of students, the Initiative has adopted a 'learning object' approach. The Le@rning Federation learning objects usually consist of one or more files designed to be used as a stand-alone learning experience (which might include audio, graphic, text, animation or some relevant mix of these components) that will make sense to the learner. Any object, for example a picture of a prime minister, can be used for a learning purpose; The Le@rning Federation learning objects are designed for a pedagogically based purpose.

So, the value of the learning object model is notionally in the way files are organised for aggregation and disaggregation. For example, an interactive animation of series circuits, which is part of a more complex learning object, is considered to have value for learning and can therefore be discovered and used independently of the original, more complex, electric circuits learning object. This supports the model, which most teachers use, of aggregating and disaggregating a variety of learning resources to meet local curriculum and student learning needs.

Specifications

The Le@rning Federation has developed a suite of specifications to support learning object development. These include:
- educational soundness
- content technical requirements
- accessibility
- rights management
- metadata application profile.

The Le@rning Federation requires compliance and conformance with each of these specifications but the main determinant of quality is evaluation of the learning object against the indicators for educational soundness. Educational soundness is the focus of this paper.

Educational soundness

A major plank for the development of high quality, pedagogically driven digital learning resources for schools is the Educational Soundness Specification. It has been written to provide the basis for all content development - undertaken by the Le@rning Federation. This specification has four principles.
1. learner focus
2. content integrity
3. usability
4. accessibility

1. Learner focus

The principle of learner focus requires that the needs of all students are addressed. Australian and New Zealand students are diverse; the demographics of each of these countries are as diverse as any country in the world. The prior knowledge and dispositions students bring to learning are just as diverse. Consider the differences between girls affluent suburbs of our major cities and recently arrived students from Africa, or students in indigenous schools. Geographically we must include relevant and realistic learning experiences for students in Broome, in Wellington and in Boort, and those learning from home in a distance education setting.

The diversity of students is even greater than the basic statistics show. Students have different strengths and weaknesses; they have a variety of preferred learning modes and styles and these change according to their stage of development and the difficulty of the content, skills and processes under study. High quality learning objects must address the spectrum of learner capability, within a specified developmental period and year level.

The Le@rning Federation learner profile information, derived from relevant demographic and educational data, and project-specific educational soundness indicators have been developed to support the process. Within the early stages of learning object design these are used to align intended learning goals and learning outcomes for differing groups of students.

Further, the Le@rning Federation has resolved that the learning objects should not just cater for the users' preferences, they should also invite the user to extend their repertoire and experiment with alternative approaches and strategies. It is therefore important that the learning object interaction design enables learners, at the targeted age and stage of schooling, to interact with, organise, represent, interpret and manage the process of learning and the information flow.

There is cognitive and physical diversity too. In Australian and New Zealand schools we have students who are gifted and talented, students with learning disabilities and students with visual and hearing impairments. These differences impact not just on the students' abilities to interact with the materials but also have implications for the contexts that are chosen and the feedback and scaffolding provided.

The learner focus principle recognises that all students, no matter what their profile, must be able to engage with the learning resources and be stimulated to enhance the motivation to learn. Not all learning objects will address the full range of student profiles as this is clearly impossible. However, across the learning objects there should be learning resources that meet the needs of all students. This requires, in some instances, creating learning objects that address particular concepts by providing alternative organisation and representations of data and information enabling achievement of equivalent learning outcomes.

2. Content integrity

The principle of content integrity is a critical component of educational soundness. Integrity of content is achieved when the content is authentic or purposeful and when learning object design takes account of:

- the ways knowledge is conceptualised within the domain

- the skills and competencies of the domain

- the ways of communicating both within and outside the domain

- the knowledge and understandings valued by various user groups and communities.

This principle concerns the content – the skills, knowledge and processes along with any contextual material – chosen for the development of learning objects. First and foremost the content must be significant. With the limited resources available for development there must be a concentration on learning that progresses the students' deeper understanding of the concepts, skills and processes described within the curriculum frameworks of each of the jurisdictions.

There are concepts and skills that are fundamental to cognitive development in the various domains and disciplines within the curriculum areas. In science, for instance, developing scientific literacy is fundamental. In mathematics and numeracy, place value, patterning and number sense are fundamental principles without which students will not be able to progress. In literacy it is vital that students are able to reproduce and produce a range of texts for a range of purposes. In LOTE the need to be able to form and decode characters is vital if a student is to develop facility with the Chinese language.

In addition to the content being *significant* it is imperative that the content is *accurate*. Accuracy is not only achieved by the absolute representation of fact, although this is important; it is also only achieved when the learning and interaction design constructively scaffolds in relation to the user response. The constructive scaffolded feedback should provide useful feedback that assists students to progress not be overly directive but must be leading to prevent misconception or unintended interpretation of data and information.

To achieve content integrity, subject matter experts and instructional designers are part of every development team with the explicit brief of ensuring content is correct and accurate, and consistent with the most recent research.

3. Usability

The principle of usability concerns the interaction of the user with the content. At its simplest level the interaction design and pathways must be intuitive and consistent. At a broader level it means that the learner should be actively engaged in constructing meaning through their interaction with the material.

The interaction must be cognitive as well as physical. Carefully chosen contexts, appropriate feedback and scaffolding underlie this principle. Providing timely and appropriate feedback on interaction with the learning resource is also part of usability. The feedback should scaffold the user towards understanding the cognitive elements of the resource as well as provide information about pathways and contexts.

Importantly, the user needs to know and understand what they are doing and why they are doing it. Fundamentally, the learning object needs to be relevant in terms of the curriculum; support the process of learning and enhance the ability of the learner to engage with its content.

4. Accessibility

The principle of accessibility is about ensuring that the learning objects comply with accessibility standards for students with disabilities and for rural and remote communities.

This principle is also concerned with utilising the capacity of multimedia to support student acquisition of standard Australian English or standard New Zealand English. Learning objects should also provide specific language support for students whose first language is not English and be appealing to and inclusive of students of all genders, socio-economic groups, ages, races and cultures.

As described previously, the range of users in the target audience is diverse. Implementation of The Le@rning Federation's accessibility principle is informed by the Center for Applied Special Technology's concept of Universal Design for Learning http://www.cast.org/udl/. The 'universal' in Universal Design for Learning does not imply one optimal solution for everyone. Instead it reflects an awareness of

the unique nature of each learner and the need to accommodate differences and create learning experiences that suit the learner and maximise their ability to learn. Online content across The Le@rning Federation initiative, is designed, developed, evaluated and delivered so that students have access to educationally sound content regardless of age, socio-economic status, race, culture, disability, gender or geographic location.

Pedagogically based learning design

The materials developed by The Le@rning Federation are based on the most recent research into how children learn and how teachers facilitate this learning. Teachers will choose the learning objects they wish their students to engage with so the students will develop an understanding of the topics or concepts under consideration within a classroom. Interaction with learning objects will be only a part of the total learning experience. Given that understanding, The Le@rning Federation seeks to ensure that these digital resources enhance the learning process and model what is known about good teaching and learning.

Engagement and interactivity

First the learning objects must engage the learner. One aspect of engagement is that the context must resonate with the target student profiles.

In order to assist developers, each project scoping brief identifies user characteristics pertinent to the curriculum area and, in some cases, suggests appropriate pedagogical approaches and lists curriculum design issues. For example, in the science brief, which focuses on scientific literacy, Year 3 and 4 students are described as being able to 'connect real and imagined experiences from the past, present and future and are beginning to make sense of these'. This contrasts with a similar learning characteristic for Year 5 and 6: 'interested in exploring topical issues and the wider community … with some awareness of the interdependence within and beyond the natural world'. These learner characteristics are designed to assist education writers, subject matter experts and multimedia developers to select contexts that connect with and, hence, engage the learner.

Fundamentally, engagement results from stimulating an emotional reaction and thereby motivating the user to participate. This is often best achieved by providing the user with a role that is central to the learning activity and authentic context. The user should be required to actively do something – manipulate the data and information – the key to connecting the learning activity and the context.

There is another component to engagement: the learning experiences must be at the appropriate level for the users. The experiences need to be challenging enough but based on a good estimate of the previous understanding of the concepts so that all students in the profile can extend their understanding. As Herrington, Oliver and Reeves (2003) profess, 'provision of real and authentic scenario-based problem-solving and investigative activities that motivate and encourage learner participation help the user to engage with the unfamiliar….by facilitating students willing suspension of disbelief through immersion in a setting' and thereby 'provide the motivation that is needed for initial perseverance'.

Some success in providing motivating and engaging learning objects is being achieved by The Le@rning Federation. During student in-school evaluation of a year 3–4 science learning object about how we breathe and the structure and function of the human lung, a student was observed, while interacting with the learning object,

placing his hands on his ribcage to check what was happening as he breathed in and out as shown in the animation within the learning object.

In another instance, students decided to test whether what was actually being demonstrated in the interactive animations about change in breathing rate in relation to changed physical activity. The students actually gathered the test equipment and started to run some tests, in an attempt to verify the concepts being presented within the learning object.

One thing that we know about learning is that it is an active process where the learner is actively engaged in constructing meaning, testing hypotheses and grappling with the ideas. This approach is largely constructivist where the user is presented with contexts and concepts that test their understanding of the concept, so promoting the development of a deep understanding of the concept, skill or process in a way that makes sense to them.

The learning design of learning objects should make the learner central to the process. Learners are situated as actors in the play, performing themselves, not as audience members or recipients of knowledge. Scaffolding and feedback provides information and ideas to allow the user to question and test their understanding and to refine their ideas as they actively participate in the 'play'.

Learners are all different: they bring with them previous conceptual understanding and often some misconceptions. The learning object interaction design can provide multiple starting points and pathways through the learning. Users can choose to adopt a particular strategy, move on to more complex understanding or to spend some time consolidating their learning. The Le@rning Federation is actively pursuing this approach to learning design and, through user evaluations, is evaluating and documenting knowledge of more effective interaction design for various user groups and within various curriculum areas.

Successful learning

Good pedagogy allows students to deconstruct and reconstruct and make meaning of their learning. One important aspect of learning is providing the facility for students to communicate what it is that they know. What does this concept mean? How can I apply my understanding to another situation? What are the components of this concept? What are the skills and processes that accompany or complement this concept?

Learning objects under The Le@rning Federation model are designed to provide opportunities for making meaning. Under the learning object model students explore a concept from a holistic point of view and explore, gradually, the components and details of the concept through their interaction with the media and the integrated scaffolding and feedback drill.

For example, a learning object like Finders Keepers developed as part of the literacy project involves a 'game' approach. The user enters a 3D house to search for and locate texts that lead to the hidden treasure. The learning object uses a series of reflective questions about a range of everyday texts to encourage students to approach reading as a purposeful activity, and understand that each text has a purpose such as to entertain, provide information, instruction or to retell an event. While this learning object provides users with a fun challenge it is very much about enabling the learners to develop an understanding that specific types of texts are designed for specific purposes. Similarly, when using the Food Chain object

developed as part of a science project, students play with the ideas of food chains in an aquatic habitat. This allows them to see the consequences of different predator–prey relationships and to investigate the ideas about food webs and the impact of environmental factors on a habitat and the organisms within it.

Constructivist learning

Constructivist learning is a pedagogical approach based on building on what the learner knows and is a fundamental principle adopted by The Le@rning Federation. The learning objects present the users with ideas and concepts, ask users to make predictions based on their understanding and to test these. The digital medium is well placed to take this approach. Users can be presented immediately with the results of their predictions or estimations and are able to refine or rethink their understanding in the light of the response.

Constructivism is about challenging ideas. In conjunction with an inquiry approach, this type of pedagogy is invaluable in moving students to a more formal understanding of a particular concept.

Constructivist learning requires changes to learning experiences. The learning objects therefore need to help students understand of concepts for themselves. Instead of memorising material, filling in worksheets, undertaking drill and practice exercises or repetitiously doing the same sort of task, students solve new problems, research and integrate information, and create knowledge for themselves. The Compound Shapes – Area Calculation Mathematics and Numeracy learning object provides a good example. It randomly builds various compound shapes and requires the user to find the area by breaking them into rectangles and triangles while applying the formula. Students can make an estimate of the area and then cut up the shape and apply the formula. Highly constructive scaffolded feedback based directly on the input of the user is displayed to provide appropriate guidance.

Inquiry

Inquiry processes are imbedded into the learning objects. We know from research into the ways children learn that students who can ask good questions and investigate the solution to problems have a much deeper understanding. Through experience with inquiry, students learn how to critically examine any given question and come to master fixed subject matter through this process. The roots of inquiry learning lie in John Dewey and the Progressive movement. As Dewey stated himself, 'Science is more than a body of knowledge to be learned; there is a process or method to learn as well.' (Dewey, 1933)

Starting with the prior knowledge and experience of students, learning objects are designed to promote:

- framing and focusing questions
- locating, organising and analysing information and evidence
- evaluating, synthesising and reporting conclusions.

Take for example the suite of learning objects from the first mathematics and numeracy project concerning number sense and part–whole relationships in number. The approach is to provide students with some possible strategies for partitioning or combining numbers to make calculations 'in their head' easier. The students use an exploratory or inquiry approach to investigate for themselves which strategies are effective. In a science object focusing on cyclone formation, prediction and action, users are required to locate, organise and analyse information and, using physics principles, explain atmospheric properties that will culminate in a

cyclonic event. Users need to synthesise the data and describe the action required to minimise the impact of various atmospheric events.

Critical pedagogy

Critical pedagogy signals how questions of audience, voice, power, and evaluation actively work to construct particular relations between teachers and students, institutions and society, and classrooms and communities. Pedagogy in the critical sense illuminates the relationship between knowledge, authority, and power (Giroux, 1994: 30). The challenge is to present the data and information relating to the concepts to be learned in such a way that assists the learner with identifying and differentiating between different points of view and perspectives presented.

John Gore, chief education curriculum officer in the New South Wales Department states in his article published in *HSC Online*:

> Critical pedagogy attempts to:
> 1. create new forms of knowledge by emphasising the breaking down of disciplines and creating interdisciplinary knowledge
> 2. provide a way of reading history to reclaim power and identity, particularly around the categories of race, gender, class, and ethnicity
> 3. make curriculum knowledge responsive to the everyday knowledge that constitutes peoples' lives
> 4. illuminate the ethical in defining cultural practices and the language that teachers and others use.

While Gore is referring in particular to the New South Wales HSIE (Human Society and Its Environment) curriculum this idea of critical pedagogy is applied across all projects being undertaken by The Le@rning Federation.

This notion of critical pedagogy underpins The Studies of Australia learning objects. The theme for the learning objects is 'Shaping Australian Identity'. Users, through characters based on real individuals situated in time and place in Australia, are invited to explore through a situated role key issues, attitudes and influences that have shaped Australia's identity. Users actively interrogate a variety of rich data and information sources, and, with various learning tools, analyse and interpret events, opinions and actions providing a way of reading history in relation to the shaping of Australian identity.

Appropriate use of the medium

The digital medium allows the use of a range of media: audio, text, graphics, video and animation. It is the judicious choice of these that is important. The media must maximise the opportunities for learning and in a way that does not jeopardise loss of engagement.

The Le@rning Federation is determined that the materials developed will enhance the learning of students. Learning objects do not replicate the types of experiences that can be offered in another medium. So if the concept under consideration is 'states of matter in science', the learning object might provide the opportunity for students to inquire into melting points of various metals: an activity not possible in an ordinary classroom. In mathematics the dynamic relationship of various representations of fractions is fundamental to one suite of learning objects. Yes, students can explore different spatial representations of fractions in a non-digital environment; but can you dynamically show the spatial representation along with the symbolic, written and numberline representations?

In a recent independent assessment of The Le@rning Federation learning objects, models and frameworks within international development, design and pedagogical contexts, the researchers conclude with the following:

> The variety of learning objects demonstrates the significant strides that the Le@rning Federation has made in the field of designing online learning materials for school-age children. They present the 'best of breed' in this area and highlight the strength that Australia has developed in this domain. The similarities of interface design show the opportunities that exist for repurposing 'content shells' to be used in a variety of curricular areas. The diversity of designs highlights the richness of approaches to creating online materials for learners.
>
> A review of the objects and of the supporting documentation demonstrate the developing national infrastructure and emerging sector strength among both public and private sector organizations to developing learning objects that enhance learning in Australia and New Zealand. This strength also highlights the significant potential that these objects have for use across the globe and for the role that Australian companies have for establishing leadership in the field.
> (Muirhead & Haughey, 2003. Unpublished draft report)

Achieving educational soundness: the process

Multi-disciplinary teams

To ensure the pedagogy implicit in the resources does indeed enhance the learning of the user is no mean task. It takes time and risks and brings to bear the skills of multi-disciplinary teams. All development teams include subject matter experts experienced in the content and approaches embedded in the resource. Instructional designers are vital to interpret the scripts to ensure that usability, navigation and interaction with the ideas contributes to the learning. Writers, experienced in the multimedia environment are there to interpret the discipline matters into engaging and relevant experiences across the target student profiles. (Sometimes these writers will be educationalists, specialised in the discipline area, but often they come from a multimedia background.)

The teams also include the engines of multimedia: programmers, graphic artists, sound artists and producers. These people are responsible for realising the ideas presented by the writers, subject matter experts and instructional designers.

The Le@rning Federation recognises that many multimedia developers come from a technical systems, software and graphic design background. They provide expertise and capability in terms of innovation and quality treatment of educational concepts and content, primarily in terms of technical application and graphical design. The resulting products usually portray finesse in performance, runtime, ease of navigation and exciting graphical and interactive interfaces.

Similarly, but from a different perspective, educational experts are often more concerned with the specifics of the content being presented and the pedagogy embedded in the resource. This is particularly the case where domain-based knowledge and information is reflected, as it would be represented traditionally when conforming to non-digital models of instructional design. Thus many digital learning resources in the education market have suffered from an over-emphasis on the technical proficiency and exciting graphical design to the detriment of sound pedagogical application and quality in terms of innovative and educationally relevant exploitation of the media.

The multi-disciplinary team approach of including expertise from both domains, employed by The Le@rning Federation, is designed to maximise the skills and knowledge of each, resulting in digital resources that optimise the benefits of both.

Iterative design process

The process of developing pedagogically based digital materials is a new endeavour. For centuries now we have been publishing print materials for educational settings. Even video and audio tapes are developed under a well-known and accepted process. But digital learning materials? We have different players in the development process. We have multi-pathways and starting points – the resource is not linear.

The Le@rning Federation is committed to ensuring the widest possible application to the broad range of profiles both in engaging the learner and addressing accessibility issues. As Boyle (2003) in his paper *Design principles for authoring dynamic, reusable learning objects* states:

> …from a software engineering perspective each learning object should be as cohesive and de-coupled as possible. This greatly facilitates re-use and re-purposing. From a pedagogical perspective, however, there is a need to create an overall coherent learning experience. These design challenges may be in conflict. A key challenge is to resolve the tensions in a creative and productive way.
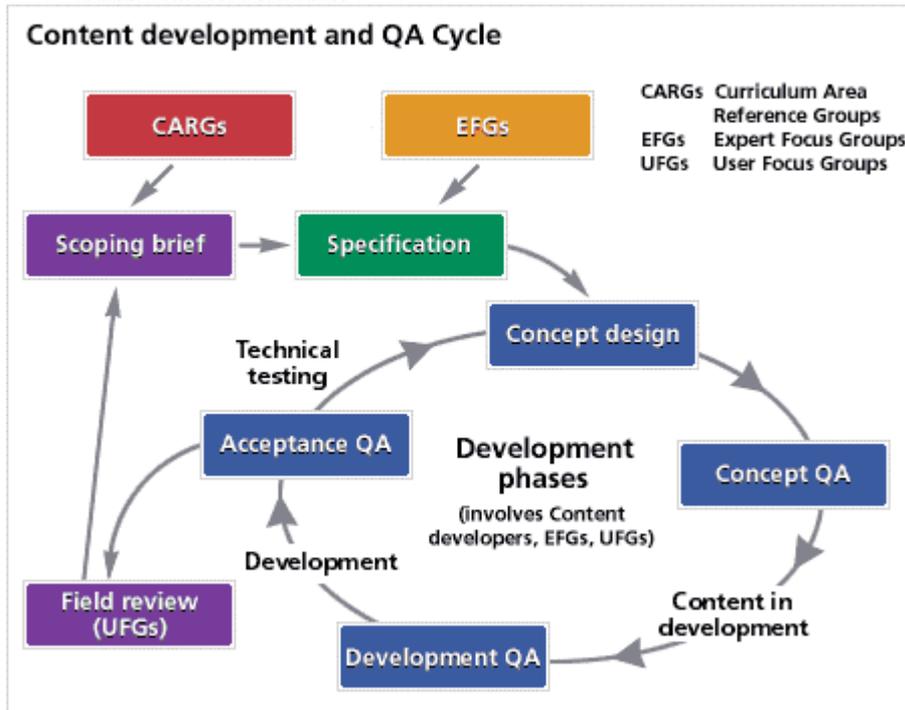
To meet this challenge the design and development and quality assurance process employed by The Le@rning Federation is extensive and iterative. At all stages, from concept mapping to publication, the materials are thoroughly interrogated by a range of people for a number of purposes. The quality of the pedagogical approach is the priority while enabling disaggregation of the parts making up the whole.

Primarily, the learning objects are designed with the potential for separation of context and content in mind, thus enabling components to be disaggregated and used for learning purposes other than that for which they were originally designed.

Further work and research is required with teachers to determine to what extent this capacity is warranted. Are teachers really able and willing to take advantage of the model, and to use the learning resources in a variety of teaching and learning situations and for different learning purposes for different student learning programs?

The Le@rning Federation has implemented a multi-stage development process for all content development projects. After the development of the project scoping brief and selection of developers, educational writers and subject matter experts implement an iterative design and development process including extensive quality assurance reviews. These processes (as shown in the diagram) aim to ensure that the content developed is:

- relevant to the needs and expectations of users
- accessible to the range of technology available to users
- usable and functional
- pedagogically sound and cohesive.

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Content development and QA Cycle

CARGs	Curriculum Area Reference Groups
EFGs	Expert Focus Groups
UFGs	User Focus Groups

Development phases (involves Content developers, EFGs, UFGs)

Educationally, there are educational specialists who examine the efficacy of the materials both from a content and pedagogical point of view. This educational soundness review is augmented by consultation with the Curriculum Area Reference Group (CARG). Officers from each of the educational jurisdictions who are responsible for developing the project scoping briefs, at each stage of development, review the materials to ensure they are fulfilling the specifications contained within the brief and are suitable for the learner profiles defined for each suite of learning objects. In addition, Expert Focus Groups (EFGs) comprising teachers examine the materials and provide feedback.

It is the users – the teachers and the students – who are the ultimate audience of the materials. User Focus Groups (UFGs) are established consisting of teachers and students across the two countries to trial the use of the resources at each stage of development. The feedback of all of these groups has proved invaluable in fine-tuning the materials and in some cases abandoning some approaches or significantly altering others.

There are, of course, technical, usability and accessibility testing regimes as well as the educational soundness review. These processes are vital in ensuring that the resources are robust and meet all principles contained within the educational soundness specification and within the technical specifications.

It should be remembered that The Le@rning Federation is charged with a research and development brief. The learning gained from the iterative development process, involving multidisciplinary expertise and the quality assurance program, is crucial for the remainder of the project. The development process has been amended as a result of the quality assurance regime. The refined project management processes enable the early evaluation of storyboards and concept maps to realise the potential and to guide development of high quality learning resources that will enhance the learning of students. This change in the development process provides the opportunity for the potential users – the teachers and students – to be more active

participants and to comment on the educational efficacy of the materials as they are being developed.

The way forward

There is a number of significant learnings to consider as we continue to develop materials that complement and enhance learning experiences for students. First, the digital medium requires a different way of thinking about the development of learning resources. The print, or even video, paradigm is not appropriate. There are new ways of thinking about learning and about presenting experiences for students; multiple starting points and pathways, and exploitation of the multimedia environment, can combine to provide rich experiences for students. But it is only through combining all resources of the development team – educational, instructional and technical – that the full potential is able to be realised.

Secondly, beware the imposition of the context. Too much emphasis on highly engaging contexts without due consideration of the learning goals and outcomes can result in highly engaging learning objects with minimal learning purpose. A context must promote learning of the key ideas that are the focus of the learning object, not inhibit or provide window dressing. Users are not fooled they know when an unpalatable 'treat' is wrapped in pretty paper. Grammatical exercises and common fractions are worth learning about should be the message, not that if you pretend that we are really investigating a real-life situation we will fool you into learning something that is good for you. On the other hand if a learning object comprises a context that is really worth solving and the user wants to then the key ideas will come through.

Thirdly, users need to be the central actor in the learning process. They must be engaged and active. They must be encouraged to experiment, take risks, inquire and extend their understanding of concepts and processes and to build their skills. Too often learning is offered as an empty vessel model: you don't know, we'll tell you and what's more we'll tell you all in the same way. The challenges are enormous but with the power of the digital medium we have the opportunity to augment what the most skilled and innovative teacher has to offer.

Finally, use of the learning objects within the initial trials in schools and classes around Australia and New Zealand has demonstrated that it is possible to develop learning objects that are relevant for each of the educational jurisdictions' curriculum. Further, learning objects have been successfully integrated into local curriculum and teaching and learning programs. However, the effective use and integration of information and communication technologies (ICTs) and digital learning resources in schools is in its infancy and there are many technological and pedagogical challenges to be overcome.

There are many other learnings and challenges for The Le@rning Federation but it is most important to recognise that this is new work. We don't have all the answers yet. There will be wrong turnings and false starts but with the rigorous processes set in place, and the commitment to developing the best learning outcomes for all our students, the progress will be smoother and the results more and more outstanding. This project has the great potential to situate Australia and New Zealand at the forefront of what is the new frontier in learning: harnessing the power of the digital age for generations of learners.

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