The Open University

Innovating Pedagogy 2012

Exploring new forms of teaching, learning and assessment, to guide educators and policy makers

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Open University Innovation Report 1

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Page 14, from Nussbaum, M., Gomez, F., Mena, J., Imbarack, P., Torres, A., Singer, M., Mora, M. E. (2009). Technology-Supported Face-to-Face Small-Group Collaborative Formative Assessment and Its Integration in the Classroom. In Preiss D. D. & Sternberg R. J. eds., *Innovations in Educational Psychology: Perspectives on Learning, Teaching, and Human Development*. Springer, pp. 295-324.

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Page 28, from Dawson, S. (2010). 'Seeing' the learning community:
An exploration of the development of a resource for monitoring online student networking. *British Journal of Educational Technology*, 41(5), 736-752.

Page 30, from Anastopoulou, A., Sharples, M., Ainsworth, S., Crook, C., O'Malley, C. & Wright, M. (2012) Creating personal meaning through technology-supported science learning across formal and informal settings. *International Journal of Science Education*, 34, 2, 251-273.

Page 33, from *Drugs and Medicines of North America*, 1884-1887, by John Uri Lloyd and Curtis G. Lloyd.

Suggested citation:
Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., Mor, Y., Gaved, M. and Whitelock, D. (2012). *Innovating Pedagogy 2012: Open University Innovation Report 1.* Milton Keynes: The Open University.

Contents

Executive summary

This series of reports explores new forms of teaching, learning and assessment for an interactive world, to guide teachers and policy makers in productive innovation. The first report proposes ten innovations that are already in currency but have not yet had a profound influence on education. To produce it, a group of academics at the Institute of Educational Technology in The Open University proposed a long list of new educational terms, theories, and practices. We then pared these down to ten that have the potential to provoke major shifts in educational practice, particularly in post-school education. We have not deliberately excluded school education, but that is not our area of expertise. Lastly, we drew on published and unpublished writings to compile the ten sketches of new pedagogies that might transform education. These are summarised below in rough order of immediacy and timescale to widespread implementation.

1 **New pedagogy for e-books:** As e-book technologies evolve, they will offer new ways of interacting with massively shared, adaptive and dynamic books. Teachers will be able to write alternative versions of text, embed graphs and simulations showing live data, add summarization, and use tools such as timers and calculators to support structured learning and formative assessment. Students will be able to share annotations or contact other people reading the same page of a book. New forms of learning with e-books could include crowd authoring (where textbooks are produced by students, for students), embedded tutoring (where readers offer to explain or discuss a difficult passage), or co-reading (where readers are automatically put in contact with others currently reading the same page).

2 **Publisher-led short courses:** These are short courses offered by publishers either in affiliation with recognised educational providers, or independently. The publisher's incentive is to understand learners in the subject areas covered by their regular publications, and to engage consumers in extended learning activities. For the learner, these courses offer self-directed learning for professionals, with institutional affiliation providing respectable 'leisure learning' products.

3 **Assessment for learning:** Assessment can support the process of learning, not just measure its outcomes. In diagnostic testing with rapid feedback, the results of summative computer-based assessment are provided immediately to learners and teachers, then used as a basis for addressing misconceptions and

providing supplementary teaching. Research from computer games has explored how continuous feedback can guide performance and improve motivation. This requires software to monitor how learners progress through the course materials, diagnose misconceptions, know when to intervene, and offer appropriate advice. A teacher can be provided with a 'dashboard' that displays the progress of each student and offers a range of actions from simple automated prompts to online student-tutor conversation. Students can be offered 'open learner models' that show their progress in relation to peers.

4 **Badges to accredit learning:** Badges offer a way of accrediting non-formal learning. A badge, analogous to a Scout badge, is awarded when a learner completes a task or challenge that demonstrates a learning achievement. Badges may be awarded by authorities, by peers, or may be automatically assigned on completion of certain tasks. Badge systems have been used to encourage participation in online help forums and to acknowledge expertise in gaming environments. New approaches support the collection and validation of badges for learning, and work is in progress to develop an infrastructure to award, manage and validate badges.

5 **MOOCs:** Massive open online courses are attempts to create open-access online courses that provide no constraints on class size. They run over a defined period of time and are open to all. The early instantiations followed a pattern of 'let's put on a course here, right now'. More recent offerings take the form of free courses based on existing university teaching materials freely available online, with computer marked assessment and certificates of completion. Some courses have engaged over one hundred thousand participants.

6 **Rebirth of academic publishing:** There are two commonly used approaches to open access publishing: the Gold route, whereby the author or research funder pays a publisher for the cost of making an article open; and the Green route, where the individual author self-archives the article. Some journals have begun to experiment with open review where the reviewers' comments are made public and not anonymised. Others adopt a low threshold for acceptance, replacing peer review selection with post-publishing commentary.

7 **Seamless learning:** Seamless learning occurs when a person experiences a continuity of learning across a combination of locations, times, technologies or social settings. Previous work on seamless learning has focused on designing software for mobile devices that allow people to carry their learning with them and to switch quickly from one learning activity to another. Recent studies have also examined how to support learning journeys. These are extended learning projects that can be accessed on multiple devices, flow across boundaries between formal and informal settings, and continue over life transitions such as school to university and workplace.

8 **Learning analytics:** Learning analytics involves the collection, analysis and reporting of large datasets about learners and their contexts in order to improve learning and the environments in which learning takes place, for example visualisations and recommendations that can influence student behaviour while a course is in progress. Current research is attempting to identify key indicators that show when a student is making good progress or is struggling. From a practical perspective, systems need to allow real-time analysis of disparate data and generate timely reports.

9 **Personal inquiry learning:** Typically, personal inquiry learning involves active exploration of an open question, with the student taking ownership of the inquiry process. Mobile phones can become inquiry toolkits. A typical inquiry might start in a formal setting, with a tutor helping students to refine their questions, continue at home or outdoors with the students collecting and viewing data, then return to the formal setting to share and present results. Inquiry learning can extend existing online or classroom learning. It also has the potential to catalyse citizen science experimentation.

10 **Rhizomatic learning:** This invokes the metaphor of a rhizome, a plant stem which sends out roots and shoots that allow the plant to propagate itself through organic growth into the surrounding habitat. Seen as a model for the construction of knowledge, rhizomatic processes suggest the interconnectedness of ideas as well as boundless exploration across many fronts from different starting points. For the educator, supporting rhizomatic learning requires the creation of a context within which the curriculum and knowledge are constructed by members of a learning community and which can be reshaped in a dynamic manner in response to environmental conditions. The learning experience may build on social, conversational processes, as well as personal knowledge creation, linked into unbounded personal learning networks that merge formal and informal media.

Introduction

We all know that global society has been transformed by interactive technology including personal computers, the worldwide web, and mobile phones. How this technological innovation has influenced the education system is the subject of much debate, with claims that it has transformed schools and extended universities, or conversely that new technology has signally failed to improve educational standards.

Less well known are the innovations in teaching, learning and assessment over the past fifty years. Arguably, the introduction of social constructivist methods into schools and the foundation of universities based on methods of open distance learning have done far more to enhance education than putting computers into classrooms. The pedagogic innovations of experiential learning, networked learning, constructionism, peer teaching, formative assessment and cognitive apprenticeship deserve to be as well known and discussed as Wikipedia, iTunesU, and Google Scholar. But to debate the relative influence of technology and pedagogy is to miss the point. Education is now inextricably tied to technology, whether through teaching with electronic whiteboards in class or sharing ideas with friends over social networks.

Our aim is to produce a series of reports that explore new pedagogies for an interactive world. The reports are intended for teachers, policy makers, academics and anyone interested in how education may change over the next ten years. By pedagogy we mean the theory and practice of teaching, learning, and assessment. This first report proposes ten innovations in pedagogy that are already in currency but have not yet had a profound influence on education. Whether, or when, they will do so depends on many factors, not least on whether policy makers and practitioners come to understand their significance. In compiling the report it became clear that the innovations are not independent, but fit together into a new and disruptive form of education that transcends boundaries between formal and informal settings, institutional and self-directed learning, and traditional education providers and commercial organisations.

> " the innovations are not independent, but fit together into a new and disruptive form of education that transcends boundaries "

The report has been written by a small group of academics in the Institute of Educational Technology and the Faculty of Mathematics, Computing and Technology at The Open University. It is not the product of expert focus group meetings, Delphi studies, or scenario-planning workshops. Rather, it is based on knowledge acquired from leading research projects, reading and writing educational research papers and blogs, holding conversations with colleagues worldwide, and surveying published and unpublished literature. We compiled the report by first producing a long list of new educational terms, theories, and practices, then paring these down to ten that have the potential to provoke major shifts in educational practice, particularly in post-school education. We have not deliberately excluded school education, but that is not our area of expertise. Lastly, we drew on published and unpublished writings to compile ten sketches of new pedagogies that might transform education. We acknowledge inspiration from the NMC Horizon Reports as well as other future-gazing reports on education. Those explore how innovations in technology might influence education; we examine

how innovations in pedagogy might be enacted in an age of personal and networked technology.

In a report written in 1993 to the UK National Commission on Education, David Wood offers a scenario of 'A Day in School: 2015 AD'. It is remarkably prescient with regard to technologies for education, including fieldwork projects supported by mobile wireless devices, learning with pen tablet computers, collaboration through computer networks, and tools for teachers to analyse the progress and outcomes of learning. Then, having offered a picture of a bright technology-enhanced future for education, the report states "if the recent past can be taken as a reliable guide to the near future, then one can have little confidence that (even if considered desirable) the kinds of developments in education that have been described will come about". The reasons for such pessimism back in the early 1990s are revealing. The main obstacle indicated in that report, of providing each learner

with a personal computer, is being overcome. New smartphones and netbook computers are powerful affordable tools for learning. The second obstacle, of developing more user-friendly and useful technology for learning is also being addressed, through an increased awareness of the importance of good design and usability. But the final impediments relate to pedagogy rather than technology and are as important now as they were then: that schools, colleges and universities are attempting to teach knowledge and skills for jobs that no longer exist, and that teachers are not fully involved in educational innovation and curriculum development. In our report, the first in a series of annual briefings, we explore current and emerging innovations in education for the 21st century, in the hope that it will guide teachers and policy makers in making informed decisions about curriculum design, course development and teaching strategies.

Reources

NMC 2012 Horizon Project to chart the landscape of emerging technologies for teaching, learning, research, creative inquiry, and information management:
http://www.nmc.org/horizon-project.

David Wood (1993) 'The Classroom of 2015', *National Commission on Education Briefing No. 20,* October 1993. London: National Commission on Education.

New pedagogy for e-books

Innovative ways of teaching and learning with next-generation e-books

**Potential impact:** high

Timescale: short (0-2 years)

Students in higher education are rapidly adopting e-books for leisure reading and some are using their e-book readers (e.g. the Kindle) or tablets (e.g. the iPad) to read course texts and supplementary materials in pdf format. Surveys of student use of iPads indicate convenience, availability and portability as benefits of electronic books and documents, compared to printed texts. A few institutions are responding by publishing their course materials in standard e-book format. However, several US surveys of student use of Kindles found a wide gap between their use for personal reading and for academic study. The devices did not support the students' current study practices such as having several documents open on a desk simultaneously, annotating pages, using sticky notes and bookmarking.

> " the real benefits will come from new forms of teaching and learning through dynamic and shared books "

The next generation of e-book readers and tablets should overcome some of these technical problems, so e-books become more like dynamic printed texts that can be annotated and compared. The HTML5 format will also allow dynamic media such as video and simulations to be embedded in the text. Publishers are also developing software for authors to update their published textbooks, and for academics and teachers to customise the books of other authors. While this may enrich books and alter the publishing process (not necessarily for the better if authors find their texts being mangled by others) the real benefits will come from new forms of teaching and learning through dynamic and shared books.

One opportunity is to link a book illustration to the data or computer code that generated it, so that these can be viewed or modified. The aim is to provide the reader with confidence that a graph or visual simulation is accurate by inspecting the underlying data and with an educational opportunity to explore the consequences of changing the data or modifying the computer code. This is part of a broader drive towards a more transparent approach to academic publishing through 'reproducible research', where an author publishes not only a finished text but also all the elements, such as source materials, data and computer code that would allow others to fully understand and reproduce the findings.

Dynamic books can also enable a more social form of study, with a group of students working together on reading, annotating and comparing one or more texts on the same topic. Each student can see the text on their e-book reader and also the annotations and comments on the text being created by the other students. For example, in the
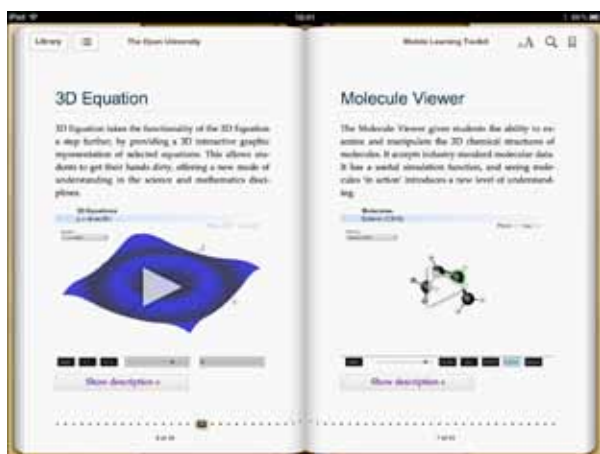
Demonstration interactive e-book from The Open University

Concept Grid method, each student reads part of a study text and highlights key concepts. The system extracts these key words or phrases as electronic sticky notes. The students must work together to put the notes into a 4x4 or larger grid, with similar concepts placed together. They also connect the concepts by clicking between the notes and identifying the relations between them. The activity requires all the students to compare and discuss their reading and to explain the concepts to each other.

On a larger scale, many thousands of readers could share the same virtual text, leaving highlights, notes and scribbles for other readers. These could be filtered by time, topic or reader, to provide layers of shared annotation. Further social tools could allow a reader to contact the note maker, asking for clarification or help in understanding the text, perhaps for a small payment. Each student could also see who else is currently reading that section of the text and request a real-time chat about its content.

A logical extension to this mass sharing of comments is for students to write additions to textbooks, offering their own interpretations, explanations and examples, which they can then publish alongside pages of the book. Book publishers would need to set up a simple system of publishing and reward for such 'book extensions'. This could lead on to crowd-authoring of complete

student e-books, on similar principles to Wikipedia. The Wikiversity site is an indication of what could be achieved, with over 18,000 current learning resources. These are currently in a limited and somewhat unattractive wiki format, but could be developed as complete open-authored multimedia textbooks. The 'Rebirth of Academic Publishing' section indicates how such open textbooks might be reviewed and published.

Another approach to innovation with e-books is to exploit the functions built into the reading devices for exploratory learning. Tablet computers not only have high-resolution-screens, but also a set of inbuilt tools including a voice recorder, camera, timer, GPS position locator, accelerometer, compass, and tilt sensor. An e-book for inquiry-based science learning could guide the reader through experiments and explorations, such as understanding properties of light and colour using the device's camera, or sound with the recorder, or Newton's Laws of Motion by attaching the device to a pendulum or cart. In other subject areas, captions for video and audio allow mixed media to be searched and compared, while live updates to graphs and tables can assist in understanding changing events in economics, politics or sociology. Online lexical systems such as WordNet and Forvo offer opportunities for learning based on e-books, so a person reading a book in a foreign language can get immediate advice about an unknown word or phrase, for example a dictionary definition, a pronunciation from multiple speakers, or examples of the word used in other contexts.

A third area of opportunity is to embed assessment into e-books. This could be as simple as reporting which pages the student has read, or as complex as providing diagnostic feedback and advice to students, based on their reading habits, notes and requests for help. There has been over 30 years of research into live help systems that track a user's interactions and offer personal and contextual advice. The challenge is to create a hybrid system that can offer simple or complex assistance, or perhaps a link to a human tutor where needed, embedded into the structure and content of a study text.

Resources

Princeton Kindle DX Pilot:
http://www.princeton.edu/main/news/archive/S26/64/38E35/

iPad Study Released by Oklahoma State University, Executive Summary, 3 May 2011
https://news.okstate.edu/images/documents/ipad_research_exec_summary.pdf

Darden School of Business Kindle Pilot:
http://www.darden.virginia.edu/web/Media/Darden-News-Articles/2010/Darden-Shares-Results-of-Kindle-Experiment/

Reed College Kindle DX Pilot. Reed College summary report:
http://www.reed.edu/cis/about/kindle_pilot/index.html

Fomel, S. and Claerbout,J. (2009). Guest Editors' Introduction: Reproducible Research, *Computing in Science and Engineering*, 11 (1), 5-7.

DynamicBooks, "the next generation of interactive textbooks":
http://dynamicbooks.com/

Economist LeanBack 2.0 "aims to examine, discuss and track the impact that new digital reading devices, particularly tablets, are having on both reader behaviours and media businesses":
http://www.economistgroup.com/leanback

THUZE is a collaborative environment for students to interact with e-textbooks:
http://www.thuzelearning.com

Publisher-led short courses

Publishers producing commercial short courses for leisure and professional development

Potential impact: medium

Timescale: short (0-2 years)

The traditional business of educational publishing is being disrupted by new types of online content and a revolt from their institutional subscribers over unsustainable charging models and practices. Some traditional media companies are responding by marketing mini-courses, either in affiliation with recognised educational providers, or independently. The aim is to sustain deep and persistent engagement of students, adding value to a publisher's wares. The courses may operate online at a distance, such as the *Economist* education courses, or involve scheduled face-to-face sessions, such as the *Guardian* masterclasses. Some compete directly with the further and higher education sector, such as the Condé Nast College of Fashion & Design year-long *Vogue* Fashion Foundation Diploma.

The courses are marketed as premium offerings, with high prices compared to university fees: the UEA/*Guardian* masterclass in creative writing runs over six months with a weekly three-hour tutorial and costs £4000. The ten-week Vogue Fashion Certificate is £6,600, and the year-long Vogue Fashion Foundation Diploma is £19,560. *Economist* Education online courses are priced around $500 for a four-hour course, or $2500 for a twenty-hour course.

One incentive for publishers to invest in short courses is that they develop an appreciation of learners as consumers in subject areas covered by their regular publications, so engaging them at a deeper level than as readers of magazines or textbooks. Courses based around set texts,

> **" being able to offer an institutional affiliation makes publisher-led courses credible as leisure learning products and legitimate as evidence of CPD activity "**

using commercial assessment products such as Pearson Assessments, provide an opportunity for further sales, as do courses that include training around specific toolkits or applications (such as those offered by Microsoft, Google and Pearson Clinical).

For the learner, these mini-courses may offer opportunities for non-formal learning previously provided by vocational evening classes. In the business sector, they may be marketed to professionals and fill a need for Continuing Professional Development (CPD). Being able to offer an institutional affiliation makes publisher-led courses credible as leisure learning products and legitimate as evidence of CPD activity even though they may not be credit bearing. The appeal

Financial Times **MBA Newslines annotation tool**

comes from being offered as attractively packaged consumer products that satisfy immediate learning needs.

Publishers are exploring innovations in education from several other directions, including integrating their content into courses, community building, and running events that generate new content. The *Financial Times* Education MBA Newslines product provides a means for integrating global financial news into the classroom. The *Guardian* Higher Education Summit provided a "CPD certified" networking event for HE managers and policy makers that not only made news, but helped deepen engagement with the *Guardian* Higher Education Network. Several O'Reilly conferences act both as live events and as generators of video lecture content that can be sold after the event.

Whilst academia currently benefits from the cachet of recognisable and highly valued qualifications, academic and education publishers are involved in training and examination businesses operating at global scale. For example, in the UK Pearson operate EdExcel for the assessment of GCSE, GCE (A-level) and BTEC/vocational qualifications. Pearson has recently bought vocational trainers Education Development International and assessment and testing providers Centiport. If education is ripe for disruption, it may be that the assessment of training and the offering of examination services at higher levels of education will provide a route by which publishers can develop credibility in the assessment and award of an ever wider range of qualification products based around their content offerings.

Resources

Guardian Masterclasses (e.g. writing, photography, computing, gardening):
http://www.guardian.co.uk/guardian-masterclasses/uea-guardian-masterclasses

Economist Education courses for international business managers:
http://economisteducation.com/courses/

Financial Times Education (e.g. MBA Newslines, integrating FT global news into the classroom):
http://education.ft.com/

Condé Nast College of Fashion & Design:
http://www.condenastcollege.co.uk/

Guardian Higher Education Summit (CPD Certified):
http://www.guardian.co.uk/higher-education

Pearson Clinical:
http://www.pearsonclinical.co.uk/Education/Education.aspx

Pearson assessments:
http://www.pearsonassessments.com/pai/

Microsoft certification
http://www.microsoft.com/learning/en/us/certification/mct.aspx

Google qualifications:
http://support.google.com/adwords/certification/bin/static.py?hl=en&page=examstudy.cs

O'Reilly conferences:
http://conferences.oreillynet.com/

These can be contrasted with a ☐grassroots☐ approach, such as
http://schoolofeverything.com/

Assessment for learning

Assessment that supports the learning process through diagnostic feedback

Potential impact: high

Timescale: medium (2-5 years)

We have the opportunity to move beyond measuring the results of learning and taking snapshots of students' performance towards integrating assessment fully into the learning process. The most immediate benefits can be made from giving students *advice for action* on how to narrow the gap between their current and desired performance. In this, computer-based assessment is embedded into the teaching materials, with constructive feedback provided immediately to learners and teachers then used as a basis for addressing misconceptions and providing supplementary teaching, perhaps followed by re-assessment.

The general approach is that students already attempt to monitor their own performance, so feedback should build on this process of self-regulation. Nicol and Macfarlane-Dick offer seven principles of feedback to promote self-regulated learning, each supported by evidence from research. These are:

1. Clarify what good performance is
2. Facilitate self-assessment
3. Deliver high quality feedback information
4. Encourage teacher and peer dialogue
5. Encourage positive motivation and self-esteem
6. Provide opportunities to close the gap
7. Use feedback to improve teaching

Each of these principles can be assisted by technology. For example, good performance could be clarified by providing students with interactive walk-throughs of successful solutions to problems.

Technology-enabled feedback can include immediate automated responses to open assignments and written student reports. The computational technique of latent semantic analysis processes a corpus of text (such as previous student work over a range of marks, or a set of model answers) to uncover similarities in meaning between words and phrases, then uses this to simulate human judgements of the coherence and style of a new piece of student writing.

Other techniques, adapted from computer games, can motivate students by providing visible indications of their performance over time, their level of achievement, and their performance in relation to peers. The software tracks the student's performance and produces an *open learner* model of performance that is shown to the student as a bar chart or a graph of progress across topics.

Such methods must be used with caution. They cannot provide the precision or the insight of a human response and there is a danger that giving continual feedback will channel a student into continually adjusting performance to match the response, rather than planning and then engaging in a fluent piece of work. Rather than the student just viewing the feedback or learner model, a more useful approach may be to have the student and the system (and in some cases a human tutor) cooperate to produce an agreed representation of the student's skill, knowledge and performance. In this way the student takes a more reflective approach to self-regulation and managing feedback.

A simple but effective example of this negotiated approach is confidence-based marking. Here, a student selects an answer to a multiple choice question and also indicates a level of confidence in that response. The student scores full marks for a correct answer, some credit for a tentative correct response, and is penalised for claiming to be confident about the answer but getting it wrong. This rewards thoughtfulness and encourages students to reflect on their understanding. A more open approach is to ask a question to which the student responds with a level of confidence in knowing the answer. Only once the student has thought about possible answers and indicated confidence are the multiple choices revealed.

**Student performance grid
(Nussbaum et al., 2009)**

Human tutors or graduate assistants can be brought into the process of assessment for learning in two ways. The first is to provide tutors with 'dashboards' showing a continuous indication of how each student is performing. One type of dashboard is a grid with each row indicating a student and each column a question. The cells show red and green for correct and incorrect answers, and amber if confidence is also assessed. From this display the tutor can see at a glance how each student is performing, and so can focus effort in assisting students showing misunderstanding, or providing help with questions where most students are performing poorly or where they are showing a lack of confidence in their responses. A version of the dashboard, perhaps with the rows anonymised, can also be shown to the students as part of the open learner model, so they can see how they are performing in relation to their peers and when to seek help.

The second way of involving tutors is to help them improve the quality of their responses to open questions. For example, tutors typically give extended comments on the written work of poor performing students, but terse responses to high quality work. Yet high achieving students also value encouragement and advice and if they cannot see other students' marks, they may not know they have performed well. The OpenMentor system assists tutors in providing clearer positive responses for high achievers and prompts tutors to advise all students about how to improve their grades. It works by classifying tutor comments into positive reactions, negative reactions, questions and answers. For each type and grade of assignment there is a predetermined benchmark of distributions of comment types. Then, when a tutor marks a new assignment, the system automatically extracts the tutor's comments, determines their type, and shows the tutor a bar chart of the difference between benchmark and actual distribution of comment types. The system has been used as a training tool for tutors and has prompted reflection and discussion about how to support students to improve in their next assignments.

" these methods represent a shift from assessing the outcomes of learning towards guiding the learning process "

All these methods represent a shift from assessing the outcomes of learning towards guiding the learning process. They also break with the previous use of computers for adaptive tutoring, where the computer tries to infer students' knowledge from their performance and then adapts the teaching with additional hints or supplementary teaching. For some topics, for example in maths or language learning, adaptive tutoring can be successful, but to do it well requires intensive analysis and modelling of the topic and possible student misunderstandings. Assessment for learning is more flexible, in that it can be easily applied to new topic areas and it involves students, computer system and tutors in a cooperation to enhance understanding and performance.

A challenge for the future is to find effective ways to combine the different methods without overwhelming the student or tutor. For example, dashboards and open learner models could be applied to groupwork and peer support, with students who have successfully answered questions offering help to those who appear to be struggling. Or students can be assigned to groups based on differences in ability, each student attempts individually to answer a question, then the students in the group discuss their draft answers and produce a group response.

Assessment for learning is a process of mutual adaptation: students reflect on, share and regulate their learning; tutors monitor and assist the learning progress; computer systems orchestrate the process, providing timely feedback and overviews.

Resources

Paper on advice for action:
Whitelock, D. (2010). Activating Assessment for Learning: Are we on the way with WEB 2.0? In Lee, M. J. W. and McLoughlin, C. eds., *Web 2.0-Based-E-Learning: Applying Social Informatics for Tertiary Teaching.* IGI Global, pp. 319–342.

The OpenMentor approach to support tutors in providing more effective feedback to students:
http://www.jisc.ac.uk/whatwedo/programmes/edistributed/om.aspx

Confidence Based Marking. Multi-guess questions where students also add a confidence value to their answer. Also taps in to gaming mechanics:
http://www8.open.ac.uk/about/teaching-and-learning/esteem/projects/themes/innovative-assessment/assessing-confidence

FEASST project which scoped a vision for formative e-assessment:
http://www.jisc.ac.uk/publications/reports/2009/feasstfinalreport.aspx

Case studies on e-assessment :
http://kn.open.ac.uk/public/document.cfm?docid=10817

A commented literature review of formative assessment:
http://purl.org/planet/Groups.FormativeEAssessment/Literature+Review

Educational games with 'stealth assessment' based on automated scoring and reasoning techniques, to support learning of knowledge and skills:
http://myweb.fsu.edu/vshute/WebinarCPD.pdf

Nicol, D. and Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice, *Studies in Higher Education*, 31 (2), 199–218.

Badges to accredit learning

Open framework for gaining recognition of skills and achievements

Potential impact: high

Timescale: medium (2-5 years)

Anyone using the Internet goes through a process of learning about the content, tools and people they encounter. This incidental learning can develop into a more structured process, as is the case when someone works through a series of Open Educational Resources (teaching materials freely available on the Web). 'Badges' offer a way of accrediting this learning that takes place outside formal educational institutions.

Example badge for skill in wildlife observation

The concept can be considered by comparison with Scouting badges. A Scout demonstrates some skill or competency to the satisfaction of the Scout leader who then makes the judgement that a badge can be awarded. This badge is then worn with pride, is generally accepted as indicating that the wearer does indeed have the capability described, and has enough value to be cited in a CV or reference. The awarder of the badge may have asked for particular tasks

to be carried out against fixed criteria, or the award could be judged on overall progression or on reported activity. Despite such badges operating outside formal education systems, they have clear value. Online badges follow the same concept, where now the activities and tasks are related to online actions. For some years they have been used in computer-based conferencing and help systems to encourage and reward helpful behaviours and to identify key individuals who can then show others that their contribution is worthy of attention.

A substantial impetus for applying badging to learning has come from the Mozilla Foundation. In 2010, Mozilla developed a White Paper describing the concept of badging and this led to work on a software infrastructure that can support the awarding, collecting and explaining of badges. The Open Badge Infrastructure (OBI) uses graphical badges, each containing an embedded link that describes it in more detail. The badges are placed within a 'backpack' that can display the badges and allow them to be categorised. The backpack is associated with a particular user and gives tools to help share them and to expose the information behind the badge, which will typically include who earned the badge, the identity of the issuer, where it was issued from, and potentially the evidence that was used to demonstrate that the award of the badge was deserved. There is some security involved in this – the backpack is associated with an ID and the data about the badge is collected from a secure server – but the security operates on the basis of trust, since these are accolades to be proud of rather than having direct value in themselves. The structure enables links to evidence, which may be a powerful way to show that real tasks have been carried out. For example, if the evidence

is a functioning website or a piece of software created by the badge holder, then that might be a more persuasive demonstration of design or programming capability than an industry certificate or even a degree.

The Open Badge Infrastructure is work in progress, but adopting it could bring several benefits: the badges appear in other places, such as Facebook and LinkedIn; the badges are portable and describe themselves; they link through to the issuer and will help spread the issuer's identity; the meaning attached to the badges is in the control of the issuer; and the approach has a fairly high profile. For badge earners, the backpack gives them a badge management utility, so users can view and group badges from different issuers, giving them greater ownership and providing a resilient infrastructure.

The education field is not the only, or indeed main, target for the Mozilla Foundation work on badging. Indeed, its preferred terminology is 'earner' rather than learner. The Foundation is particularly interested in whether industry is prepared to use badges to recognise capabilities. One large-scale pilot is exploring how badges can be used alongside job adverts within the American Manufacturing Institute in order to match individuals to requirements of the adverts and also to identify strong candidates to recruiters. Other work supported as pilots through the Digital Media and Learning competition (backed by the MacArthur Foundation) include nature exploration and financial skills.

" badges can return some of the structure and reward that is needed to keep learners on track "

There are options for adopting badges as a more organised approach to self-awarding. The DIY-University is an exploration of the value of building your own qualification as a means to motivate and encourage reflective learning: if the only person you need to convince is yourself then badges may be ideal. To consider badges solely as rewards for personal effort removes many of the potential problems of issuing badges, but may well limit the impact. It is perhaps more interesting to see how an objective and standardised structure for badging can be developed. If we compare a badge-based system to a formal system of accredited learning, the badges can reflect experiences on the way to the final credits with award based on some review or examination of the evidence collated by the badge earner. This view of educational content in terms of badges that can be earned could bring benefits in design of learning materials and in motivation for the learner. The impact on course design would be to encourage the setting of goals around badges. In Peer 2 Peer University where this approach has been explored, these are described as 'challenges'. Such challenges are more obvious to the learner than a breakdown of materials into sets of outcomes typically described for a course. The badges permit the learner to split a module into smaller units each with its own meaningful reward. For example, a computing course may offer badges for understanding hardware, programming concepts, programming ability (at various levels), and for completing an independent project. These are of value in themselves and can start to generate profiles for learners that follow different paths through the same material.

Badges appear to offer a natural match to Open Educational Resources. These currently lack the context and drivers of accredited material. If they are used for self-study then assessment is optional and the learner chooses which topic to follow next. Badges can return some of the structure and reward that is needed to keep learners on track.

Resources

Description of the Open Badges Infrastructure and the chance to earn a first badge and put it in a backpack:
http://openbadges.org/

Information on the goals, missions and vision around Open Badges:
http://wiki.mozilla.org/Badges

School of Webcraft Mozilla Badges pilot:
https://wiki.mozilla.org/Badges/Pilot_programs

Peer 2 Peer University which is running the School of Webcraft pilot:
http://p2pu.org

Work by Anya Kamenetz on DIY-University:
http://diyubook.com/

Edupunks' Guide:
http://edupunksguide.org/

Lincoln University experimental use of Open Badges Infrastructure:
http://coursedata.blogs.lincoln.ac.uk/2012/05/23/release-the-badges

Accreditation of Open Educational Resources:
http://wikieducator.org/OER_university/Home

Massively Minecraft system of awards for participants:
http://www.massivelyminecraft.net/awards/

MOOCs

Massive open online courses

Impact: medium
Timescale: medium (2-5 years)

Massive open online courses (MOOCs) are attempts to create open access online courses that provide no constraints on class size. In contrast to open courseware, MOOCs are self-managed by groups of learners and teachers and run over a defined period of time, typically 6-12 weeks. MOOCs are open to all, have no formal entry requirements, and can provide a framework for 'badge' based recognition. They may support opportunistic ad hoc engagement with individual activities or resources, as well as a more disciplined commitment to the course as a whole. MOOCs can be purely informal offerings, or opportunities for independent learning aligned to a formal course, or semi-formal courses offered by an institution for informal certification.

Early adopters in this field were George Siemens and Stephen Downes, who have run an open course (CCK) since 2008. Their latest version is the Change MOOC which has a different expert and topic each week. These original informal instantiations with thousands of participants followed a pattern that might be summarised as "let's put on a show (course) here right now". In part, these offerings resembled the rhizomatic learning model in which course contributors would produce activities and readings on a weekly basis, often hooked around a live webcast or webinar.

More recent types of MOOC offer existing university course materials openly online, with computer-marked, copyrighted assessment exercises and certificates of completion. These have attracted in excess of one hundred thousand participants to a course. David Wiley, Alec Couros

> " it was this freedom to experiment beyond the constraints of formal education that attracted many of the early adopters "

and Jim Groom have all adopted the model of the boundary-less course, with an institution running an existing course for fee-paying students on campus and making it open to all (e.g. DS106.us). The Stanford Artificial Intelligence course was run as a one off and so is a typical MOOC, but the Udacity suite of courses on Computer Science, Physics and Statistics has now moved towards more open access and continuous presentation. A partnership with VUE, a testing company run by Pearson, will allow Udacity students to sit secure exams in one of 4000 centres worldwide. A number of universities offer courses with the Coursera site, and Harvard and MIT have announced a joint initiative called EdX for open courses. MOOCs are emerging from early experiments into a more corporate institutional approach.

The financial models of these commercial offerings have not been revealed, but the obvious approach is to sell accreditation and additional services around the course offering, thus implementing a form of 'freemium' approach to education. Benefits of MOOCs for the institution include increased profile and a possible increase in student numbers. They also provide an experimental space for exploring new pedagogy, models of support, and use of technology. If learners are not paying fees for a course, then the contract is altered, lowering the support requirement on the provider.

It was this freedom to experiment beyond the constraints of formal education that attracted many of the early adopters, although recent large-scale offerings have adopted more traditional and formal pedagogic approaches.

Work on digital scholarship shared online by one learner in response to study on the Change MOOC

For learners, there is the opportunity to take part in a structured course alongside a student cohort studying at the same time. There are also disadvantages for institutions and for learners. MOOCs have tended to be less well structured than formal courses, so they may damage reputation. For a university, giving away all of a course plus the student experience may reduce student recruitment. These kinds of impacts are not known yet as the experiments so far have mainly been one-off events, rather than institutional commitments. Some learners express frustration and confusion at the mixture of technologies required for greater learner independence. A study of MOOCs by McAuley and colleagues found that student dropout is much higher than in conventional courses. This may be a result of the lack of financial commitment, frustration, or simply because learners have gained what they needed at an early stage of the course.

As a topic and an approach the MOOC is gaining currency. For instance, at the recent EdgeX conference in India there was enthusiasm for such open courses to provide at least a partial solution to some of the scaling issues in Indian education. Key issues to be resolved will be in accrediting the outputs of MOOCs, and in making them financially sustainable for institutions.

Resources

Change MOOC, weekly courses introducing major contributions to instructional technology:
http://change.mooc.ca

Digital storytelling course:
http://ds106.us

Stanford University Artificial Intelligence course:
https://www.ai-class.com/

Udacity classes on Computer Science, Physics and Statistics:
www.udacity.com

Coursera, provider of free courses from universities:
https://www.coursera.org/

EdX partnership between MIT and Harvard:
http://www.edxonline.org/

EdgeX conference on Disruptive Educational Research:
http://www.edgex.in/

McAuley, A., Stewart, B., Siemens G. and Cormier, D. (2010). The MOOC Model for Digital Practice.
http://www.elearnspace.org/Articles/MOOC_Final.pdf

Rebirth of academic publishing

New forms of open scholarly publishing

Impact: medium/high

Timescale: medium (2-4 years)

Academic publishing of journal articles has an unusual business model: those who carry out a significant part of the work (authoring, reviewing, and editing) often receive no remuneration for it, and indeed may need to pay to see the results in print or to gain online access to the journal. Models where access is free and open appear to be gaining traction and indicate an alternative path. These alternatives also have some difficulties in offering sustainable revenue but have distinct advantages in supporting the primary purpose of writing academic papers, which is to get them published and read. It is therefore important to understand and plan for a change from paid access to academic knowledge to access based on openness, and to appreciate the implications that has for measures of quality as well as for costs. Proponents of open publishing must confront the need to maintain academic quality, as a means for authors to establish academic credentials and for readers to have assurance that the work is rigorous, accurate and novel.

A measure of quality comes from through the label 'peer-reviewed'. The peer review process provides a check and feedback on whether papers contain content worthy of dissemination, but this process

> " proponents of open publishing must confront the need to maintain academic quality "

also is flawed. The classic approach of blind review, where the reviewer does not know the identity of the author, is challenged by the ability of an Internet search to put together the clues from within an article to reveal the writer's identity as the reviewer carries out checks of references and examples. The anonymity of review tends to lead to a static and invisible process: the resulting article may have been highly praised, or just made the grade, there is no way of telling. Peer review for the reviewer is a voluntary activity that is hidden and lacking in reward, which makes it unreliable for the editor who can exert little pressure and may then accept reviews of varying quality, driven by the need to meet publication dates. Alternative models for reviewing also exist. The visible commenting that takes place through blogging and discussion gives an obvious basis for feedback and discussion. The *Journal for Interactive Media in Education* (JIME) followed such an approach from its first online publication in 1996 with initial success, but the ingrained model that a review was a private comment on an article restricted engagement. A 2006 experiment by *Nature* also found that there was limited take up of the opportunity for open comment either by authors or reviewers. Research assessment such as that carried out in the UK under the Research Excellence Framework reinforces traditional approaches; while any item may be considered within the framework, a blind peer-reviewed article in an established journal is still seen to offer the greatest security of shared value.

The pressures of a broken system with limited signs that people are ready for a change mean that renaissance in the publishing system may take some time, but there are also encouraging indications of alternatives. Funders, institutions and individuals are all expressing dissatisfaction with closed systems. The Research Councils UK are adopting mandated routes to open access,

prestigious universities are declaring publishers' fees to be too expensive, and grassroots campaigns against working with and reviewing for pay-for-access systems are attracting considerable support.

Refining the alternative models is an important step. There are two commonly used approaches to open access publishing. The first is the Gold route, whereby the author (or their institution or research funder) pays a publisher for the cost of making an article open. The second is the Green route, wherein the individual author self-archives the article, for instance in an institutional repository. The Gold route has also been criticised as being a slow and expensive route to open access whilst the Green route has the limitation that the self-archived version may differ from the final accepted version. These restrictions imply that some further refinements are likely to develop. Some publishers now agree to simultaneous open access and charge for a better finished and presented print or academic e-book edition. Finding value in social connections and tools to help manage collections of articles points to a service model that moves away from individual journals to aggregated publishing, such as that offered by Mendeley.

The Public Library of Science One (PLoS One) journal has simplified review judgements to focus on quality rather than impact or relevance and may offer a model that can more easily move to open judgement. ArXiv has gone further to publish articles prior to review. Both of these approaches have achieved great acceptance within their subject areas. While free access on the basis of the author paying to publish correctly recognises that the publishing process has costs, it also calls into question impartiality and favours those with resources. Research councils and some universities are establishing funding mechanisms to support such publishing but these are not common, though now recommended as the way forward in a review commissioned for the UK government (the 'Finch report'). Athabasca University in Canada has taken a broad approach by establishing a principle that it is prepared to use its resources to support open publishing through a publishing press that publishes online for free under an open licence, by establishing open access journals, and by funding those who wish to publish openly.

Looking for free-to-publish options that combine publishing with social, multimedia and barrierless routes for authoring and for reading, while maintaining academic quality, seems an attainable goal though with challenges to be met as we move towards digital scholarship.

Resources

Directory of open access journals:
http://www.doaj.org/

Public Library of Science (PLoS):
http://www.plos.org/

Journal for Interactive Media in Education (JIME):
http://www-jime.open.ac.uk/

Budapest Open Access Initiative, 2002:
http://www.soros.org/openaccess/read.shtml

Clarke, R. (2007). The Cost Profiles of Alternative Approaches to Journal Publishing, First Monday, 12 (12). Available at:
http://www.uic.edu/htbin/cgiwrap/bin/ojs/index.php/fm/article/viewArticle/2048/1906

Davis, P.M. (2010). Does Open Access Lead to Increased Readership and Citations? A Randomized Controlled Trial of Articles Published in APS Journals, The Physiologist, 53 (6). Available at:
http://www.the-aps.org/MayCC/publications/tphys/2010html/December/openaccess.htm

Finch, J. (2012). Accessibility, sustainability, excellence: how to expand access to research publications. Report of the working group on expanding access to published research findings - the Finch Group. Available at:
http://www.researchinfonet.org/wp-content/uploads/2012/06/Finch-Group-report-FINAL-VERSION.pdf

The Cost of Knowledge campaign:
http://thecostofknowledge.com/

Altmetrics, the creation and study of new metrics based on the Social Web for analysing, and informing scholarship:
http://altmetrics.org

Nature peer review trial:
http://www.nature.com/nature/peerreview/debate/nature05535.html

Research Councils UK updated position statement on access to research outputs:
http://www.rcuk.ac.uk/documents/documents/2006statement.pdf

Seamless learning

Connecting learning across settings, technologies and activities

Impact: medium-high

Timescale: medium (2-5 years)

Seamless learning is when a person experiences a continuity of learning across a combination of locations, times, technologies or social settings. Such learning may be intentional, such as when a learning activity starts in a classroom then continues through an informal discussion with colleagues, or online at home. It can also be accidental, for example when an interesting piece of information from a newspaper or television programme sparks a conversation with friends. Seamless learning can be a collective or an individual process. It can extend across time and locations, offer ubiquitous access to learning resources, encompass physical and digital worlds, engage multiple types of device, and integrate different approaches to teaching and learning.

Although seamless learning does not depend on personal internet technology such as a tablet computer or smartphones, these devices can enable a fluidity of learning activity. What might have once been 'dead time', for example travelling on a train or waiting to collect a child from school, can now be used to browse information, continue an online conversation, or make a note to be expanded later on a desktop computer. The seams that were once apparent – between learning episodes in formal and informal settings, at specific times of the day, in resource-rich places, or with available experts – can blur or disappear.

Seamless learning may form part of a wider learning journey that spans a person's life transitions, such

> " seamless learning occurs across contexts and may form part of a wider learning journey that spans a person's life transitions, such as from school to university or workplace "

as from school to university or workplace. Social networking sites such as Facebook can function as personal learning environments that allow projects to be maintained online, over long periods of time. The Speak Up 2011 Survey found that 46% of high school students had used Facebook as a collaborative learning tool.

The SEAMLESS project was a 3-year study that aimed to develop an infrastructure for sustainable and continual seamless learning within a primary school in Singapore. It pioneered the use of mobile devices as learning hubs to integrate personal learning tools and resources and to provide a single place to store the learning history and resources for each student. A similar year-long study with postgraduates using a Mobile Learning Organiser found the students did not want a separate personal learning environment but preferred to conduct their learning with standard office software and social network tools.

A central issue is how institutions and teachers should engage with these tools for shared

seamless learning: should they offer students a single system to manage their learning across time and space, or should they support students in using their own wide range of individual and social tools for learning? Personalised learning systems include extended e-portfolio systems such as PebblePad that belong to the learner rather than the institution, with tools for students to organise resources, support incidental learning, and reflect on their learning experiences. Commercial tools that can support seamless learning include Dropbox and Google Docs which make it possible to store resources and engage in learning activities on a shared web server, accessed from multiple personal devices.

Students generally value anytime anywhere access to learning material and like to have assistance when stuck, but do not want their online activities to be controlled or to be interrupted by administration messages and offers of teaching. One solution is for the institution to offer a 'one stop shop' where learners can find up to date information, resources and assistance where and whenever they have a need. Such 'light touch' integration of on-demand learning resources with a student's online life contrasts with a typical institutional Virtual Learning Environment where the student must break out of the flow of learning to log into a corporate server, navigate a course structure, and browse long teaching documents.

While mobile devices allow people to carry their learning with them, to access online resources

from multiple locations, and to switch easily from one activity to another, there are practical challenges. Patchy internet connection can cause gaps in the flow of activity and may require complex management of learning resources so they are always accessible and synchronised. Limited battery life may restrict use. There may be problems with managing access across network configurations, for example a university network will have one set of passwords, home may have another, thus requiring students to have the technical knowledge to traverse these settings.

There are also social challenges. Students may have only limited access to a home computer and in some situations, for example offender learning in prisons, access to online resources or social networks may be denied. There may be increased demands on the teacher to track and record student progress, which might not be easy when students are engaging with technology outside the monitored environment. For students who do not engage in seamless learning through choice or circumstance, this may affect group work. If seamless working is assumed but some students are not in contact with the rest of the group, this raises tensions within the student group. Where students use commercial platforms such as Facebook there are issues as to who owns or has rights over data hosted on that platform.

Seamless learning can best be seen as an aspiration rather than a bundle of activities, resources and challenges. In a 1996 paper introducing the concept, Kuh proposes that what were previously distinct experiences of learning (in-class and out-of-class; academic and non-academic; curricular and co-curricular; on-campus and off-campus) should be bound together so as to appear continuous. Institutions can take a deliberate stance to support seamless learning by encouraging students to draw on supplementary learning resources outside, to see themselves as continuous learners, and to use students' life experiences to make meaning of material introduced in classes.

Resources

Speak Up 2011 survey mapping a personalized learning journey:
http://www.tomorrow.org/speakup/2012_PersonalizedLearning.html

PebblePad personal learning system:
http://www.pebblepad.co.uk/

SEAMLESS project: Looi, C.-K., Seow, P., Zhang, B., So, H.-J., Chen, W. and Wong, L.-H. (2010), Leveraging mobile technology for sustainable seamless learning: a research agenda. *British Journal of Educational Technology*, 41, 154-169.

Six principles for creating seamless learning: Kuh, G. D. (1996). Guiding Principles for Creating Seamless Learning Environments for Undergraduates. *Journal of College Student Development*, 37 (2), 135-48.

Mobile Learning Organiser:
Corlett, D., Sharples, M., Chan, T., Bull, S. (2005). Evaluation of a Mobile Learning Organiser for University Students, *Journal of Computer Assisted Learning*, 21, 162-170.

Wong and Looi have proposed ten dimensions of mobile-assisted seamless learning: Wong, L-H. & Looi, C-K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature, *Computers and Education*, 57 (4), 2364-2381.

Learning analytics

Data-driven analysis of learning activities and environments

Impact: medium/high

Timescale: medium (2-5 years)

Learning analytics have emerged during the last decade from the much broader field of data analytics. As companies set up internet operations, they saw the potential of 'big data': the vast datasets produced by online interaction. In order to increase revenue and market share, they developed business analytics. Amazon, for example, used customer buying patterns and ratings to develop its powerful recommendation engine, supermarkets introduced loyalty cards to track buyer behaviour and, more controversially, insurance companies began to harvest lifestyle data in order to estimate life expectancy.

The introduction of virtual learning environments (VLEs) brought big data to education. This prompted the emergence of educational data mining (EDM) from the broader field of data analytics, as computer scientists and statisticians began trying to extract value from these new datasets. They were able to apply well-established data-mining techniques to harvest and prepare data, and to investigate features that could be identified automatically. Cluster analysis and classification made it possible to distinguish between novices and experts in learning situations, the method of association rule mining identified common characteristics of students who did well or who dropped out, and sequential pattern mining was used to identify the routes taken by learners as they worked their way through course materials.

These early, data-driven approaches were pedagogy neutral – they were not based on theories about effective methods of learning and teaching.

This changed as online and blended learning became more widespread and researchers began to apply ideas from the learning sciences to their work. The introduction of social network analysis to the data-mining toolkit marked a shift towards a more theory-driven approach. Social network analysts were informed by the views of Vygotsky, who argued that learning takes place through social negotiation, and by Wenger's work on communities of practice.

In the last five years, political concerns have made this field more prominent and have led to concerns that it has been over-hyped. US political parties had been growing increasingly concerned that international benchmarking was showing US educational standards slipping, thus reducing its future ability to compete with other countries. A series of reports and articles from the US-based EDUCAUSE foundation suggested that analytics could offer a solution by helping to increase student retention and success rates. These attracted political interest, and funding for the area began to increase. EDUCAUSE worked hard to establish the importance of analytics and also to clarify the terms used to describe them.

By 2008, educational data mining was an established field with an international society, journal and annual conference. It remained data driven, with an emphasis on the development of tools and algorithms. Analytics, on the other hand, were now clearly focused on learning and teaching. An increasingly clear distinction is now made between 'academic analytics' and 'learning analytics'. Academic analytics are focused on the needs of the institution, such as raising recruitment, retention and pass rates. Learning analytics are concerned with the needs of learners and teachers and so focus on understanding and optimizing learning and the environments within which it takes place.

The current flagship example of learning analytics is the Signals project run by Purdue University, located to the south of Chicago. Signals are formative assessments presented to students in near real time – no one has to wait until the end of the week or the end of the semester to receive feedback. The project has attracted funding from the Gates Foundation and, through commercial partnership, Signals is now being employed in other US universities.

Signals gathers data about students' characteristics such as academic background, effort as indicated by engagement with online elements of the course, and performance as reflected in their grades. Information about preparation, performance and effort are combined to generate signals. These are presented as traffic lights: a green signal shows that all is well, amber suggests some areas of concern, and red flags up significant problems. These colours are not presented to students and tutors in isolation; they also trigger messages and interventions.

" the challenge now is to bring together datasets and expertise from within and beyond an institution, in order to implement powerful analytics that have a positive and measurable impact on learning and teaching "

Purdue reports a strong relationship between use of Signals and retention rates. When students enrol for courses without Signals the retention rate is 70%, when they enrol for one or two courses using Signals the retention rate is significantly higher, and when they enrol for three or more

courses using Signals the retention rate rises to 93%. Feedback from students suggests that the majority consider they obtained a higher grade as a result of the Signals project.
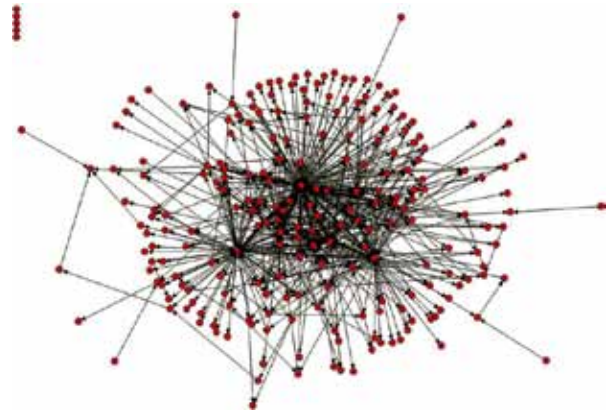
SNAPP visualisation of student online activity (Dawson, 2010)

Another example of learning analytics is SNAPP. The University of British Columbia is using this tool to provide real-time visualisations of forum activity, showing who is communicating with whom and to what level. SNAPP integrates with common commercial and open source VLEs, including the standard version of Moodle. It can be used to identify students who are disconnected and are therefore at risk, to pick out key information brokers within a class, to find potentially high- and low-performing students so teachers can better plan interventions, and to show the extent to which a learning community is developing on a course. It can also support reflection on practice – showing, for example, when staff have focused attention on certain groups or when individuals have dominated course interaction.

Distance learning organisations are well placed to exploit analytics for learning, drawing upon detailed learning and teaching datasets they have built up over many years. Researchers at The Open University are taking a lead in the related areas of social learning analytics, visual analytics, learning analytics for accessibility and the sharing of open and linked data. The challenge now is to bring together datasets and expertise from within and beyond an institution, in order to implement powerful analytics that have a positive and measurable impact on learning and teaching.

Resources

Purdue University Signals system:
http://www.educause.edu/EDUCAUSE+Quarterly/
EDUCAUSEQuarterlyMagazineVolum/
SignalsApplyingAcademicAnalyti/199385

SNAPP tool presenting student online network data in a readily interpretable user-interface:
http://research.uow.edu.au/learningnetworks/seeing/snapp/index.html

LOCO-Analyst increasing teachers' awareness of the learning process going on in their classes:
http://jelenajovanovic.net/LOCO-Analyst/

GISMO student monitoring and tracking system:
http://gismo.sourceforge.net/index.html

Moodog that shows teachers how students interact with online course materials:
Zhang, H. and Almeroth, K. (2010). Moodog: Tracking Student Activity in Online Course Management Systems, *Journal of Interactive Learning Research*, 21(3), 407-429.

Check My Activity (CMA) allowing students to compare their own activity in Blackboard against an anonymous summary of their course peers:
Fritz, J. (2011). Classroom walls that talk: Using online course activity data of successful students to raise self-awareness of underperforming peers, *The Internet and Higher Education*, 14 (2), 89-97.

Blackboard Analytics for Learn module, designed to help users gain insight into user activity, course design and student performance data:
http://www.blackboard.com/Platforms/Analytics/Products/Blackboard-Analytics-for-Learn.aspx

Social learning analytics:
Buckingham Shum, S. and Ferguson, R. (2011). Social Learning Analytics. Technical Report KMI-11-01, Knowledge Media Institute, The Open University, UK.
http://kmi.open.ac.uk/publications/pdf/kmi-11-01.pdf

Personal inquiry learning

Learning through collaborative inquiry and active investigation

Impact: medium

Timescale: medium (2-5 years)

When John Dewey, over 100 years ago, proposed inquiry learning as a basis for science education, he also advocated that the problems to be studied should relate to students' experiences, with the students as active learners posing questions to which they genuinely want to know the answer, carrying out investigations that relate to their own needs and concerns, and discussing emerging findings with peers and experts.
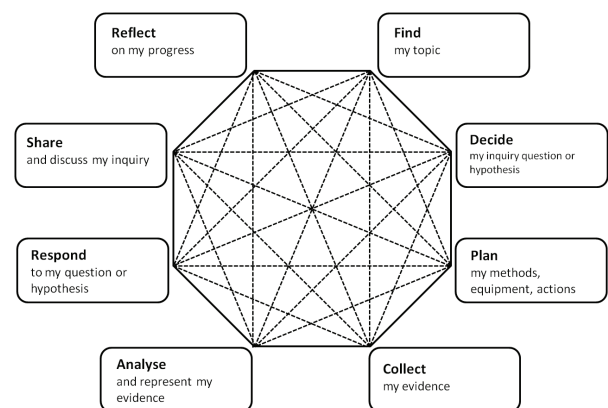
A central aspect of such personal inquiry learning is that students, individually and collectively, should take ownership of the inquiry process. For this to happen they should gain a clear understanding of the process and their agency in acquiring scientific knowledge. They should come to know what kind of questions are scientifically appropriate, how these can be framed as valid inquiries, who they can find and trust as scientific informants, what

kind of studies are appropriate, why it is important to collect reliable data, how this can be analysed and presented as valid evidence, and how the results of an inquiry can be shared and discussed. A typical inquiry might start with an online class where a tutor helps students to form and refine their questions, continue at home or outdoors with the students collecting and viewing data, then return to the formal setting to share and present results.

If learners are expected to engage in learning processes modelled on scientific practices, they need tools that offer them investigative powers equal to those of scientists. Such inquiry toolkits are becoming more affordable as mobile phones become scientific instruments equipped with embedded sensors, camera, voice recorder and powerful computer.

Students also need to understand and engage in the entire process of inquiry, as shown in the illustration. Some points to note from this representation are that: an inquiry can start at any phase (for example, by analysing another person's evidence); the process forms a cycle, with reflection suggesting further topics to investigate; although there is a systematic progression from one phase of inquiry to the next, this is not a fixed

> " if learners are expected to engage in learning processes modelled on scientific practices, they need tools that offer them investigative powers equal to those of scientists "

Representation of the personal inquiry process (adapted from Anastopoulou et al., 2011)

order of activity; the phases are inter-connected so, for example, the initial question or hypothesis is revisited after the evidence has been collected.

Although inquiry learning emphasises the responsibility of learners to pose and investigate questions, it also emphasises that these are skills that need to be learned, so the teacher has a crucial role in guiding and supporting the cycle of inquiry. This realisation has led to the development of toolkits for teachers and learners to manage the inquiry process and to access and share large datasets.

The Personal Inquiry project has explored how a teacher and learners can be equipped with personal tools to orchestrate the inquiry process. The aim is to support the entire inquiry process and to enable a seamless transition from a teacher working with students to select appropriate questions and to plan an inquiry, through students individually or in teams collecting data in a variety of locations with the software providing checks on accuracy and method, to teacher and students collectively sharing, analysing and discussing results.

WISE is a free inquiry science environment where students can examine real-world evidence and engage in scientific debate. Web-based software guides students to gather evidence, collaborate and reflect, with tools for data visualisation, modelling, simulation and assessment. Other personal inquiry projects include LETS GO, which is developing a set of mobile 'open inquiry' tools for collaborative outdoor investigations, and SCY, where students work on inquiry missions supported by computer models and simulations to analyse the data and artifacts that emerge from the learning process.

Recent research into inquiry learning has exposed some difficult challenges. Learners may be motivated by addressing personally meaningful questions, but this requires background research, careful planning and self-management of complex learning processes. It has proven difficult to generate questions that can be explored with available tools and in the surrounding environment, leading to a repetition of projects to measure water quality or air pollution. There is also what Edwards and Mercer have termed the 'teacher's

dilemma', where a teacher may have to act against established classroom practice by holding back answers in the interests of sustaining students' self-directed inquiry. But students expect experts to provide answers, so they may not tolerate attempts by a teacher to propose open questions or claim not to know the correct answer.

A practical difficulty comes in integrating the results of fieldwork back into the classroom activity. Not only will there be technical difficulties in merging and sharing data, but also the teacher needs to improvise around the emerging findings. Such disciplined improvisation presents the challenge of building a teaching session around the students' collective experience.

The difficulties that educators face in implementing inquiry learning stem in part from a contradiction between the way they are expected to teach and how they learned their craft: teacher training is still dominated by traditional pedagogies, and a practice-based science activity typically covers only one fragment of an inquiry. A possible alternative would be to guide educators to perceive their own work as a site of inquiry, posing questions regarding their students' learning, proposing conjectures as to how to support learning, formulating these as learning designs, and implementing and evaluating these designs.

For the future, there is an opportunity to promote widespread public involvement in scientific investigation by combining citizen science with inquiry-based learning. Through social web technologies for organising groups of people with shared interests, volunteers could form teams to propose and investigate shared questions, by methods that range from online psychology experiments and surveys, to observations of the natural world. An indication of how this might be done is the iSpot community, currently with over 18,000 registered users, that engages in sharing and interpreting observations of wildlife. If facilities can be added to propose questions and manage the inquiry process, then people without formal scientific training will be able to act as research teams and explore the science that affects their lives.

Resources

Personal Inquiry project and nQuire inquiry learning toolkit:
www.nquire.org.uk

WISE Web-based inquiry science environment, a free on-line science learning environment for students in grades 4-12 created by a large team around Marcia Linn at the University of California, Berkeley:
http://wise.berkeley.edu

Stanford Mobile Inquiry-based Learning Environment:
http://suseit.stanford.edu/research/project/smile

LETS GO project for open inquiry science learning:
http://www.celekt.info/projects/show/20

Science Created by You (SCY) project to develop a science inquiry missions:
http://www.scy-net.eu

iSpot community for identifying and sharing wildlife observations:
http://www.ispot.org.uk/

Rhizomatic learning

Knowledge constructed by self-aware communities adapting to environmental conditions

Impact: unsure, could be high

Timescale: long (4+ years)

Rhizomatic learning invokes the biological metaphor of a rhizome where the stem of a plant sends out roots and shoots, each of which can grow into a new plant. Rhizomes resist organisational structure and have no distinct beginning or end; they grow and propagate in a 'nomadic' fashion, the only restrictions to growth being those that exist in the surrounding habitat. Seen as a model for the construction of knowledge, rhizomatic processes hint at the interconnectedness of ideas as well as boundless exploration across many fronts from many different starting points. Dave Cormier has done most work on this as a theory, and he suggests that rhizomatic learning is a means by which learners develop problem-solving skills for complex domains.

For the educator, supporting rhizomatic learning requires the creation of a context within which the curriculum and subject knowledge are constructed from contributions by members of the learning community, and which can be reshaped and reconstructed in a dynamic manner in response to changing environmental conditions. For example, political dissidents may learn together about the changing politics of their country, or citizen scientists may set up collective experiments that analyse locally collected data leading to further questions. As Cormier puts it, "the community is the curriculum". This open syllabus represents the scope of the local habitat that the rhizomatic learning process can explore and provides the context for a community-negotiated curriculum.

FIG. 81.
Fresh rhizome of Actæa alba (large specimen, natural size).

The learning experience may build on social, conversational processes, as well as a personal knowledge-creation process, through the creation of large, unbounded personal learning networks that may incorporate formal and informal social media.

A MOOC can be seen as an example of rhizomatic learning, where students are expected to operate in a networked, open manner and offer peer-support, but the concept is broader than a single course or event. At the University of Regina, Alec Couros runs an open course in educational technology. Students in this class work from a curriculum created through their own negotiations of knowledge and form their own personally mapped networks, thereby contributing to the rhizomatic structure in their field of study.

> **" curriculum and subject knowledge are constructed from contributions by members of the learning community, and which can be reshaped and reconstructed in a dynamic manner in response to environmental conditions "**

Research with adolescent gamers by Kathy Sanford, Liz Merkel & Leanna Madill at University of Victoria looked at how how gamers' experiences revealed the complex learning systems in which they contributed, created, and participated in their gaming communities. The authors of the paper conclude that there is "no fixed course" in gaming, and that their subjects actively blurred the boundaries between producer/consumer, teacher/learner, and individual/collective.

Production of The Open University short course T151 Digital Worlds used something akin to a rhizomatic course development process for the first draft of the course, in which a loosely specified syllabus was explored across several fronts by means of a series of short blog posts published on a public online blog. Separate branches of the "course rhizome" were connected via category tags allowing particular strands to be developed over different periods of time.

One advantage of a rhizomatic approach is that it is more 'network native' than many other pedagogic concepts. It promotes peer support, learner responsibility and an appreciation of the power of the network. It can, however, be frustrating and challenging for learners (Cormier reports that he faces a rebellion every year in his class when he adopts it), confounding their expectations of the role of an educator. It is probably less robust than other approaches, although ultimately it may lead to a more sustainable attitude to learning for the individual. There are elements of rhizomatic learning which could be deployed in higher education courses, particularly at postgraduate levels, to utilise the benefits of studying with peers and having access to a global network.

Resources

Dave Cormier's review of rhizomatic learning:
http://davecormier.com/edblog/2012/04/08/a-review-of-rhizomatic-learning/

The open course by Alec Couros on educational technology:
http://eci831.ca/

Blog for Open University Digital Worlds short course:
http://digitalworlds.wordpress.com/

Paper on rhizomatic learning in gaming communities: Sanford, K., Merkel, L., and Madill, L. (2011). "There's no fixed course": Rhizomatic learning communities in adolescent videogaming, *Loading*…, 5 (8). URI:
http://journals.sfu.ca/loading/index.php/loading/article/view/93

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