



A Case Study:

How Scotland Has Leveraged e-Learning
to Improve Student Outcomes

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Executive Summary

Scotland has deployed e-learning in secondary schools and colleges for more than a decade, with both educational and political success.¹ Lessons learned from Scotland's experience in establishing its SCHOLAR program on a national scale may prove useful as the United States creates a new set of Common Core State Standards and the two Race to the Top consortia develop assessments aligned to the adopted educational standards.


SCHOLAR is the largest sustainable e-learning program for schools in the world. Created by Heriot-Watt University based in Edinburgh, it delivers cost-effective online, interactive learning courses and underpinning e-assessment to more than 400 Scottish secondary schools, both public and private, in subjects ranging from science and mathematics to business and languages. SCHOLAR is designed for 16- to 18-year-old students, to help make them college- and career-ready, and now reaches more than 90 percent of that population.

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The e-learning program rests on five basic principles:

- Technology should serve the learning and accessibility needs of the student
- Assessment is inextricably linked to learning and teaching
- The student is placed firmly at the center of the e-learning strategy

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- Performance is measured by improvement against national targets and international benchmarking
 - The “achievement gap” between the top and lesser performing students should be reduced.

Scotland’s educational system is more akin to that of the United States than to the rest of the United Kingdom. Over the past 10 years, it has achieved a greater percentage of students entering college and university (around 48 percent) than the UK, even though Scotland’s average income is lower than England’s and it has urban areas of severe deprivation. Students who used SCHOLAR performed on average half a grade better in their final end-of-year examinations for the Scottish Qualification Authority,² which sets the core curriculum. The most marked effect was on the bottom quartile of students, allowing these students to progress to college.

The key lessons learned from the SCHOLAR program that could serve as a model for the U.S. Common Core State Standards and assessment consortia include: (1) creating quality e-courseware, where content and assessment are inextricably linked; (2) grounding assessment policy on strong research principles; (3) employing subject champions in the learning and teaching transformation; (4) convincing the teaching profession of the vision for this educational paradigm; and (5) ensuring a strategic political structure is in place for the whole program.

RECOMMENDATIONS

1. Ensure strong political commitment and structure
2. Create high-quality e-courseware
3. Keep the focus on the students
4. Establish buy-in with the teaching profession from the start.



Overview of the Paper

The bulk of this white paper describes how SCHOLAR has transformed e-learning in Scotland. It starts with the background and design of the program and concentrates on Computer Aided Learning in Mathematics, which has been at the forefront of e-assessment since 1985 on the university level with pioneering diagnostic, self-testing, monitoring, and motivating formative assessments that were integrated into the SCHOLAR program in secondary schools, aligned with new courseware, in 2000. It also describes SCHOLAR's reach today; the development of e-courseware; how relevant research in assessment has been integrated into online learning content to improve outcomes; accessibility and a critical view of QTI; and the necessity of teacher involvement. The next section briefly describes the governance and financing of SCHOLAR and the ingredients that have contributed to the educational and political success of the program. The paper will then discuss how Scotland's experience relates to the U.S. context and offer recommendations for the U.S. consortia.

How SCHOLAR Has Transformed e-Learning in Scotland

1. BACKGROUND AND DESIGN OF THE SCHOLAR PROGRAM

When SCHOLAR started in 1999, computer connections to Scotland's schools were via modems and telephone lines. A decade later, technology has advanced considerably, but the original technical design and underlying e-pedagogy of the program have stood the test of time.

Heriot-Watt University has pioneered e-assessment since 1985. Its Computer Aided Learning in Mathematics project³ employed network technology to deliver what has become known as a blended learning approach at the school/university interface. Traditional “face-to-face” lectures continued, but conventional tutorials were replaced by computer classes. The burden of checking students' constructed answers to mathematical questions and then supplying feedback was shared between the tutor and the computer. A weekly computer tutorial, introduced with formative e-assessment and automated feedback, was particularly effective for large groups of engineering and science first-year undergraduates.

The design of the formative e-assessments, developed over 20 years, has played a key role in four distinct ways:

- **Diagnostic tests** are used at the start of the course to provide a baseline of each student's mathematical skills.
- **Self-tests** enable students to respond to questions with the knowledge that no record is being kept of their performance. The computer supplies feedback, allowing students to boost their confidence.
- **Monitoring tests** record students' answers and scores (the more competent students had used this type of test from the start). The record of each student's performance is available to both student and teacher, thus aiding the learning process.

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- *Motivating exercises* serve to engage the most gifted and talented students by posing more difficult questions.

These four uses of formative testing were a feature of computerized learning for a decade before ongoing educational research concluded that the computer could be used, in part, to measure the performance of, and motivate, students (Beevers et al. (1995)).

2. SCHOLAR'S REACH TODAY

When SCHOLAR's program of e-learning courseware was started in 1999, five subjects were covered: biology, chemistry, computing, mathematics, and physics, taken by young people in their penultimate and final, and pre-university, years of school in Scotland. In 2000, the materials were piloted in four of Scotland's 32 education authorities (the U.S. equivalent of school districts). By 2004, all 32 were subscribing, via an annual fee, to access the e-learning courses and the professional development program for their teachers.

Today, SCHOLAR provides more than 30 e-learning courses, covering the complete curriculum—a range of science, mathematics, language, and business subjects—to in excess of 100,000 registered students and teachers in more than 400 schools across Scotland, in both high-density urban and rural environments. The program incorporates interactive online materials, containing animations, simulations, video/audio, and discussion boards, within a proprietary virtual learning platform. The SCHOLAR subjects all include formative e-assessments, of various types, throughout the course. In 2009–2010, users completed more than 8.5 million page accesses.

Further, the SCHOLAR group has delivered separate summative e-assessments in higher mathematics to schools since 2007. A seamless transition from formative to summative assess-

ment is vital to any sound strategy using state-of-the-art assessment software if the policy of the national accreditation body is to introduce e-assessments.

3. DEVELOPMENT OF E-COURSEWARE

It is critically important to commit to producing high-quality e-learning materials that align with the core curriculum; in Scotland's case, that is specified by the Scottish Qualification Authority. E-assessment is integral to the pedagogical design of the content and is not an “add-on.” It must be carefully aligned with the national examinations, or graded, so that students and teachers are confident that it meets educational standards.

In establishing the learning materials, respected subject specialist teachers from the school sector joined with technologists from Heriot-Watt University's Learning Technology Center to form the authoring team headed by a member of the university staff. The teachers were assigned full time for one or two years. Efforts were made throughout the process to create an innovative environment. For example, fortnightly “show and tell” presentations were held in which a subject team would present to the whole SCHOLAR team its work in progress. The authors would also be drafted to awareness-raising sessions, as presenters, to hear firsthand the plaudits and criticisms of the material. E-assessment required a specialist group to work with all of the subject teams.

It was continually reinforced that the material should be interactive and engaging and simply not “text on the web,” and in this way make the most use of the power of the media. This was captured in a live document, the Author Guidelines, to ensure that students took part in “active learning” every few minutes. The multimedia employed—online materials containing animations, simulations, video/audio, and discussion

boards—were crucial to effect this, although cognizance had to be taken of the bandwidth of the school networks at the beginning.

Each small subject team divided the curriculum into topics that covered roughly 10 student effort hours comprising five hours of formal online tutoring and five hours of further independent study: a typical week's work in that subject. A 120-hour one-year course in Scotland comprises three 40-hour units, with each unit made up of eight to 10 topics to be taught in 40 hours with an equal amount of self-study. The SQA structure requires each student to pass a minimum competency test at the end of each unit: a small hurdle to demonstrate basic knowledge, understanding, and application of the topics encountered. Satisfactory completion of the three units in each subject permits the student to take a final examination which remains, to date, paper-based. The SCHOLAR resources include self-testing exercises, end-of-topic assessments to monitor progress, and motivating examples to stretch the more talented students. The courseware also contains end-of-unit tests so that students can practice for the SQA competency test, which currently can be taken either online or on paper.


Project management is crucial to delivering content by the deadline. The timescales have to acknowledge the lead time that teachers require to assess the quality and relevance of the material to their teaching in the following academic year. In Scotland, this raised production issues and required the use of subcontractors and consultants to ensure that deadlines were met. Some of the animations and simulations were contracted out, but the educational outcomes and brief for the activities were defined by the authors, using a guide commissioned for this purpose, and quality was checked before publication. The costs of producing these elements were high, and therefore the process had to be managed carefully and expensive interactivities or technical developments were appraised against their educational impact.

Experience in the classrooms over time has identified other key factors for successful formative assessment, namely:

- Close adherence to a syllabus, its outcomes, and examination practice
- Generation of accurate and appropriate feedback to different types and levels of test
- Examples of method as written by a subject expert for students to review
- Applications sufficiently engaging to motivate gifted students
- Well-designed reports for both students and teachers
- Professional development support for teachers to encourage and learn new practices.

Over the years, other subjects have been added to the SCHOLAR portfolio with the same assessment philosophy throughout. The extensive portfolio now includes languages, business, information technology, human biology, and art and design as well as the original five core subjects. Additional subjects, such as English language learning, are under development. As part of its commitment to continual enhancement, the SCHOLAR science portfolio is under revision to accommodate the government's new strategy—Curriculum for Excellence—to reshape the skills of students for the challenges of the 21st century.

Independent and self-funded evaluations are required as the program progresses. Ideally, an independent consultancy firm should be employed at the outset. In the initial stages of the SCHOLAR program, evaluations of different scale and focus were carried out for management requirements. For strategic rea-



sons, a major evaluation should be planned, at an appropriate stage, where the outcomes are defined by the stakeholders and subscribers. As an example, the positive impact of formative assessment, which is integral to the learning and teaching strategy, was borne out by the Scottish government evaluation of SCHOLAR by Livingston and Condie (2004), who concluded that students who had used SCHOLAR performed on average half a grade better in their final end-of-year SQA examinations. The most marked effect was on the bottom quartile of students, allowing these students to progress to college and university.

4. THE USE OF RESEARCH TO IMPROVE OUTCOMES

To convince the teaching profession and other stakeholders of the novel SCHOLAR approach, it was important to stress that the educational design was based on sound research principles. Research has been constantly commissioned to analyze issues and data generated from SCHOLAR. It has been an exciting process and one that has enhanced the e-assessment system through frequent upgrades, based on the massive datasets, from SCHOLAR over a decade. Results have been published and disseminated as a way of developing dialogue with others in this field (see, for example, some early work on the issue of partial credit by Beevers et al. (1999)), and other work is used internally to improve the service to teachers and students.

In the early years of this decade, for instance, researchers at Heriot-Watt University worked with colleagues at SQA to investigate the medium effect and the role partial credit plays in mathematical testing. Details can be found in the articles by Fiddes et al. (2002) and McGuire et al. (2002). In summary, it became clear that the provision of optional steps was an important feature of an educationally rich e-assessment system. When optional steps are added to a

question, the student can choose when to accept help, which encourages the independent learner. Confident students can often solve a mathematical problem in one or two stages. However, less able students need further “scaffolding” to support their learning. This places the decision making in the hands of the students, providing a solution that enables them to express their partial knowledge in cases where they cannot complete the whole question.

From 2003 to 2005, PASS-IT,⁴ an initiative developed to research the impact of assessment, investigated the role of e-assessment in mathematics at all levels of Scottish secondary education. The research outputs (Ashton, et. al (2004, 2005, and 2006)) were incorporated into SCHOLAR from 2007 onward, further enhancing the educational value and effectiveness of the program, particularly its accessibility, reporting capability, and mathematical rendering.

5. ACCESSIBILITY AND A VIEW OF QTI

Accessibility has been an important ingredient from the outset. For example, the accessibility of the e-assessments was tested by students at the Royal Blind School in Edinburgh so that sight-impaired youngsters could benefit from the new resources. The resources they used were the same as their sighted colleagues but with screen reading, or magnification technology, aiding the process. Technology does have the ability to level the playing field for disadvantaged learners and can play an important role for such individuals in extending their life chances.

It is worth stressing that, although aware of the technical work within the Question and Test Inter-operability (QTI) movement, SCHOLAR has not adopted it for a number of reasons. QTI does not properly address educational issues and favors the large commercial companies. The deployment of randomization,

mathematical answers, and optional steps are all beyond the QTI current specification, but all are needed to deliver an effective mathematical e-assessment program. These features of e-assessment design require students to construct mathematical answers to mathematical questions, and SCHOLAR rarely relies on selected response questions, which many teachers perceive as “dumbing-down” their subject.

6. TEACHER INVOLVEMENT

The SCHOLAR ethos has insisted that students be placed at the center of the learning process.

This is deeply significant, as the teachers no longer become the purveyors of knowledge and move to a more tutorial style. Such a style places greater demands on the teaching profession.

At the start, SCHOLAR organized staff development for teachers on a subject-by-subject basis. This early awareness-raising exercise, undertaken by the authoring teams, took place before the e-learning materials had been fully completed. So the teaching profession was involved with the program from the start, seeing examples of the new resources, understanding their use in the classroom, and learning how the student reports and feedback would enhance their teaching. Teachers need substantial lead time in preparing for change and accommodating a new approach into their lesson planning. Furthermore, the school management teams need to be aware of the potential conservatism in the profession and provide the resources and training for effective use of blended learning using educational technology. There was some

early teacher resistance to SCHOLAR out of fear that it would be used as a way of reducing teacher numbers. When school facilities improved (e.g., more reliable and faster Internet connections, introduction of data projectors and whiteboards into the classroom), those initial fears dissipated.

As materials became available to the four pilot educational authorities, it was possible to introduce an induction program mainly for teachers who headed academic departments. Then, as classroom use became embedded, good practice emerged and this was showcased at further professional development events aimed at department heads or at the annual SCHOLAR conference.

About half SCHOLAR’s operational budget is spent on professional development. This includes:

- A dedicated training team of experienced teachers, traveling across Scotland to advise individual educational authorities, schools, and their teachers
- Liaison with the local education authorities to identify development needs
- E-learning induction for students
- Marketing awareness-raising resources, including online professional development, throughout the nation’s secondary schools and colleges
- Good practice guides in each subject created by the training team.



The provision is free at the point of use and that teachers can rely on a long-term, financially secure program that responds to curriculum changes

The Structure and Support of SCHOLAR

It is possible that none of the educational advantages cited in the previous sections would have gained wide acceptance without strong management and sound administration. This section briefly describes the structural underpinnings of the SCHOLAR program and ingredients that have contributed to the educational and political success of the program.

1. THE GOVERNANCE AND FINANCING OF SCHOLAR

SCHOLAR acquired a solid political base across Scotland with the establishment of the SCHOLAR Forum, a nonprofit partnership between the Association of Directors of Education in Scotland (ADES) and Heriot-Watt University. ADES is made up of a director from each of the 32 educational authorities, one of whom and two senior academics from Heriot-Watt University form the SCHOLAR Forum Management Board. The SCHOLAR Forum is the legal vehicle established to transform educational practice, manage a national continuing professional development program for teachers, and deliver a large scale e-courseware resource at a low cost, currently about £2 (\$3.10) per subject, per student. The economies of scale ensure that additional subjects do not greatly affect the subscription rates, and this is a powerful argument in the present economic climate.

Additional finance is sought from other sources to develop new subject courseware following extensive consultation. The key point, however, is that the provision is free at the point of use and that teachers can rely on a long-term, financially secure program that responds to curriculum changes. Meanwhile, the private sector joined SCHOLAR; school fees within the private sector are paid by the parents. Education colleges also joined SCHOLAR as individual members to allow students who had left secondary education or who were employed to improve their formal education.

In general, SCHOLAR reinvests its subscription income in three main ways:

- Realigning the learning materials to any curriculum changes introduced by SQA
- Improving the learning platform and website
- Providing a strong market-led professional development program for teachers (in fact, as described above, roughly half the operational budget is spent on professional development).

2. KEY SUPPORT FOR E-ASSESSMENT IN THE UNITED KINGDOM

Several key national groupings have played a role in the development of e-assessment for mathematics over the years in the UK. Of relevance to this white paper has been the emphasis on resources for the transition from secondary school to university.

In 2007, the e-Assessment Association (eAA) was formed in the UK to support the growing number of e-assessment professionals working in all sectors of education and training. The eAA is a nonprofit, independent, professional body that aims to promote the effective use of e-assessment in support of learning by seeking to advance understanding of its concepts and practices; encouraging individuals and organizations to make good use of e-assessment;

explaining the issues to the public; and influencing educational policy.

As part of this mission, the eAA has mapped out its policy starting with automated assessment in which the computer sets, marks, provides feedback and creates reports as a user works through a test as in the SCHOLAR materials. Winkley (2010) presented the collective findings of an eAA expert panel—principles that SCHOLAR has, for some time, put into practice. In summary, the experts concluded that:

- Technology should not drive teaching and learning but should ensure that it serves them
- Practitioners should build on assessment research principles
- Item development designers should create a more complex question structure for automated assessment than is provided by multiple-choice testing or its variants
- Systems should supply fast and accurate feedback as students progress through a test
- E-assessments should enhance the whole learning experience by employing the efficient use of data generated during tests to create well-crafted reports.



Adaptability and Recommendations

There is a political imperative in Scotland that the educational provision support the country's economic performance by using its limited educational resources to best effect, especially in science and engineering. SCHOLAR has been a remarkable success in building a national e-learning resource that is capable of transferring to other developed countries with a suitable digital infrastructure.

As stated earlier, within Scotland, each of the 32 education authorities pays a nonexclusive license fee for access to the online materials and the service is subject to contract. If one were to set up a structure in the United States, each governing state could act similarly with a lead state managing the content provision while all governing states in the Race to the Top consortia could be responsible for the hardware and infrastructure and staff development programs, albeit saving money through shared provision of training materials adapted to specific needs. A “cookie cutter” model is one that reduces the risks associated with scaling an activity of national importance. Building the capacity to implement a large-scale program quickly relies on management with executive power and responsibility. Scotland has shown, John (2006), that it can be successfully accomplished on a scale commensurate with a single state—all of Scotland has a population (over 5 million) equivalent to that of Colorado—with a small administrative team and an operational budget of around £1million (\$1.54 million) per year. With a flexible approach, the lessons arising from the innovative SCHOLAR program can help inform the Race to the Top consortia.

To that end, four recommendations are offered:

1. ENSURE STRONG POLITICAL COMMITMENT AND STRUCTURE

- Establish in each participating state a nonprofit organization similar to the SCHOLAR Forum with a small management board that can wield political and educational influence

- Adopt a common business plan in which, after the initial investment, each state organization is expected to be financially sustainable, by a subscription model, from school, district, or state funding
- Agree on a common consultation framework in each participating state with a partnership ethos
- Choose a “lead” state to develop the e-assessments against the agreed core curriculum.
- Build accessibility into the resources from the start
- Make the learning materials interactive and engaging, so students take part in “active learning” every few minutes
- Provide exercises, including real-time reports, to measure and motivate students—both those who require assistance and those who seek a “stretch”
- Allow credit for partial learning to build students’ confidence.

2. CREATE HIGH-QUALITY E-COURSEWARE

- Include experienced, gifted, and respected teachers as part of the authoring team to prepare prototype assessments not limited by the current QTI specifications
- Form a small authoring team of these teachers and educational technologists/computer experts ensuring that accessibility is built into the resources from the start
- Identify other mathematics and English/language arts “champions” in each governing state to oversee the quality of the materials.

3. KEEP THE FOCUS ON THE STUDENTS

- Ensure that students are given instruction in using the e-learning resources

4. ESTABLISH BUY-IN WITH THE TEACHING PROFESSION FROM THE START

- Showcase resources and prototypes in an awareness-raising series of meetings for the participating states to gain momentum and feedback
- Use the feedback to improve the prototypes and integrate the core assessments into common learning materials and then pilot the courseware across the schools in the consortia
- Form a training team of experienced teachers to advise across the state
- Build into the framework an effective plan for the professional development of teachers
- Create a national support and training network for professional teachers working in e-assessment.

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