Report Summary for the report by STEM-ED Scotland on "Building a New Educational Framework to Address the STEM Skills Gap".

This project sets out "a new Educational Framework for STEM education", up to a level qualifying the learner to progress to higher education in Scotland. The project is set in a post-school context, for learners returning to study in a college.

Context

This study was approached in a 'green field' spirit, building afresh without reference to current provision, using up-to-date perspectives of what is most important, and deserves most priority, in STEM education. At present, college students take either a selection of the standard school individual subject qualifications or, more often, units of school courses may be selected from a variety of levels and subjects and are then aggregated into an Access course for HE. Whichever tack is taken, the courses studied, and their assessment, are very content focused. We believe that such an approach is out-of-date and can be much improved on.

In the Scottish school system, there is a major curriculum reform under way, driven by the Curriculum for Excellence vision (CfE). The new model we have developed in this project is, we believe, in tune with the basic principles underlying this reform. Our approach, which adopts a broader view of learning than has been traditional, is skills led, focuses on deep learning and is learner active in style of delivery.

All of these characteristics are championed by CfE. However, particularly in its cross-disciplinary connections, our approach is significantly further developed than seems likely to emerge from the current review of school subject qualifications.

Design principles for a new framework

The four driving educational priorities adopted in our framework are:

1. to engage the learner's interest and active participation in study
2. to build the key STEM-relevant skills
3. to develop and progressively deepen understanding of core ideas, insights, tools and strategies
4. to explore a wide range of specific applications reinforcing the power, reach and value of the skills and core ideas in a way that provides challenge and attainable achievement. The main purpose of learning in this context is to support future application of the skills and understanding gained, thus ensuring readiness for further study or for progressing in a career.

Retention of detail tends to dominate current assessment regimes. In our approach assessment will be designed to demonstrate growing capability, to the learner as well as to the assessor.

The way in which our four educational priorities can be achieved :

1. We plan to engage and motivate the learner by actively engaging him in his own learning and using specific applications to provide challenge.

2. We have classified and documented the STEM-relevant skills under nine headings:

   S1 Learning, study, self-organization and task planning
   S2 Interpersonal communication and team working
   S3 Numeracy: assessing and manipulating data and quantity
   S4 Critical and logical thinking
   S5 Basic IT skills
   S6 Handling uncertainty and variability
   S7 Experimentation and prototype construction: design and execution
   S8 Scientific analysis
   S9 Entrepreneurial awareness

   In our full report each of these areas is considered under a series of sub-headings and for each subheading we have provided 'characteristic statements about the learner' that should characterize possessing the skill at a given level of study. A particular study exercise can then be audited to confirm which sub-skills are addressed.

3. For the sciences we have reviewed 'the key explanatory models and storylines' across physics, chemistry, the biosciences and earth systems science. A much more detailed statement of 'the big ideas of science' is given in our main report, than many authors have expressed in the past as a concise list of around a dozen one- or two-line statements. We believe our much fuller version is much more useful for informing course design: our statements could be described as 'ideas about the world' expressed in a way that one would hope that a learner reaching a given level would understand. Our statements are designed to reflect the expected level of core understanding at the point of entry into higher education. For mathematics, engineering and for computing & information sciences we describe, key techniques, insights and methodologies where experience and skills should be developed by the same stage.

4. A wide range of specific applications will be chosen to reinforce the power, reach and value of the skills and core ideas in a way that provides challenge and attainable achievement. At the same time the links between the different disciplines will be highlighted.

A specific exemplar: new Access to STEM course

We have applied the above approach to the design of a new Access to STEM course, as a potential alternative to the existing Access to Science and Technology programmes that are run by several colleges across Scotland. These courses are accepted as preparation for entry to relevant first-year degree programmes in Scottish universities. Our course

is pitched to provide entry to first-year science, engineering, mathematics and computing programmes.
In terms of our full listing of key explanatory models and storylines in the sciences, it would be impractical to address every aspect in a single year's course. They are the hoped-for destination in understanding from the whole period of 3–18 education. We propose that the full list should be a reference resource for the course. In practice we selected shorter lists of key study areas for each of the sciences to be covered in the Access to STEM course itself, which in effect ensures that a large proportion of the storylines are addressed, and explicitly referenced. We settled on a course model with 25 Units, with the full course organized to involve five cycles, in each of which a set of five Units would be studied. Each Unit is characterized by a main theme, as indicated by its title, but the way in which each is addressed is such that cross-links abound, where the same ideas or skills are applied in quite different contexts. The interconnections and interdependences of the STEM subjects, and their reliance on a common base of skills, is made evident. An indication of the novelty of this course design can be seen from a simple list of the Unit titles (see table below). The course design, with its 25 Units, was arrived at on 'green field' principles, to implement the model we had formulated and to meet the demands we had placed on it. In judging the scale of the learning effort required we concluded that the first cycle should be set at the preceding year level (SCQF level 5). This would be accommodated either within a lower-level preparation course, which is already taken by many access course students, or by well-qualified entrants being exempted, or being given a cut-down version in a short bridging course.

Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Numeracy	Energy sustainability	Calculus	Statistics	Information systems
Atoms and molecules	Reactivity	Eukaryotic cells	Materials	The universe
Forces, motion, energy	Electricity	Radiation	Prosthetics	Nanotechnology
Earth processes	Equations and graphs	The human organism	Industrial chemical processes	Genetics
Ecosystems	Study of a domestic appliance	Investigation of a large infrastructure project	Commercial case studies	Analysis of a commercial application

The course would involve the learner in portfolio building and include regular formative assessment exercises. Time would be allocated for reflective review between cycles, and for final review and assessment after cycle 5. Once the Units were fully designed we carried out a number of audits, tracking the considerable range of cross-references made to the various skills, concept lines, methodologies and themes that the course was designed to address.
Unit summaries and unit details can be obtained at our website www.gla.ac.uk/stem and by clicking on to the STEM Skills Gap Project.

Unit and Course Implementation

The main reason why implementation of our new model will take time to complete is that the course design, the learning and teaching approach it adopts, and the nature of the learning outcomes sought, constitute a sea change compared with current practice. Along with many of the people we have discussed our proposals with, we are confident that the new approach offers considerable benefits. However, there are bound to be lessons to learn from early experience. Simply to validate and then immediately to offer the new *Access to STEM* course in its entirety would be to take significant risks with a whole cohort of students. Hence we are aiming to encourage an incremental and progressive approach to adoption:

- We hope to find opportunities to offer small-scale pilots first, with one or two new-style Units embedded within an existing programme.
- We hope to test at an intermediate level, with a cluster of new Units offering a more substantial modification of an existing programme.
- We then hope to implement the full *Access to STEM* programme.
- We hope to be able to offer support for early implementers in terms of detailed implementation, and in CPD-type support.
- We would hope that, from the first pilot applications onwards, clear feedback should be obtained on the outcomes, from learners themselves, from the lecturers involved and, subsequently, from lecturers on courses that learners go on to study.

We have held very productive meetings with representatives from SWAP-West, SWAP-East and with several FE Colleges. Before any college will show an interest we need to get at least two units validated and to pilot these units in a college.
We are currently in discussions with SQA about the possible validation of two units and the possibility of piloting these units. Colleges have shown interest in a number of units but on consultation with SQA we have decided on two units for a possible pilot these are:

- **Energy sustainability**
- **Nanotechnology**

SQA currently have no units in their NC catalogue on Nanotechnology and the Energy Sustainability unit is thought to have wide appeal in different NC and Access type courses.

Looking for Volunteers!

We are looking for a college or colleges to volunteer to pilot one or both of these units. At present these two units are not written in the approved SQA format and so changes can be made to content in consultation with pilot colleges.

<u>What will a college gain by volunteering to pilot a unit?</u>

- The two units can add new relevant topics to existing courses

- Colleges will be consulted on course content which may be adjusted to suit particular needs
- A teaching pack will be supplied for each unit along with exemplar assessment material
- A contribution will be made towards equipment needed to run the unit if a college is chosen to run the pilot

What will the college require to do for the pilot?

- Trial the unit package with a group of students
- Report back to STEM-ED periodically throughout delivery on progress, highlighting areas which are going well and areas of concern
- Complete an end of unit form giving student success.

If you are interested in potentially taking part in this pilot or want further information please contact me at m.finlayson@bio.gla.as.uk or phone me at 0141 330 8486 or 01294 221420.