The Royal Irish Academy's submission to the STEM Education Review Group

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The Royal Irish Academy/Acadamh Ríoga na hÉireann ('the Academy'), Ireland's national academy for the sciences, humanities and social sciences, welcomes the opportunity to make a submission to the Science, Technology, Engineering and Mathematics (STEM) Education Review group, established by Seán Sherlock TD, Minister for Research and Innovation, to explore the potential of research into STEM Education, particularly at primary and post primary level. This submission was prepared by the Academy's working group on STEM education chaired by Professor Alan Smeaton*. The views expressed in this submission are not necessarily shared by each individual member of the Academy.

Key Points

- Initial teacher education (ITE) and continuous professional development (CPD) programmes need to continue to adapt more inquiry-based approaches to teaching science and mathematics.
- Higher Education Institutions (HEIs), in combination with the network of Education Centres (originally Teachers' Centres) and MOOCs (Massive Open Online Courses), could deliver STEM education CPD.
- The primary and post-primary STEM curriculum should be shortened to make room for a more in-depth form of engagement with students, a richer student experience and alternative forms of assessment, so that students have more opportunities to apply and develop their scientific skills.
- The Teaching Council should be given the responsibility for recognising and registering discipline-specific teaching accreditation in the STEM area.

Background

The nature of science and discovery has always been based on repeated observation of a phenomenon until some hypothesis emerges and then a theory is formed: a process that leads on to our eventual understanding of the phenomenon. Current teaching of Science, Technology, Engineering and Mathematics (STEM) subjects in Ireland's schools does not equip our students with the tools to achieve a deeper understanding of these subjects. It is important to note that education and training in the STEM area face many challenges. Perhaps surprisingly, one challenge is the ease with which we can now lay our hands on quality information at any time, anywhere. The approach of 'I'll look it up on Wikipedia' combined with rote learning of materials is a short-cut in studying STEM subjects, which provides some knowledge but no understanding. Another challenge as outlined in a previous Academy submission to the National Council for Curriculum and Assessment (NCCA)[1] is that a successful science curriculum should simultaneously stimulate an interest in science helping to produce a scientifically literate population as well as supporting the continued flow of future potential scientists. This reflects the reality that within the student population there will be students whose formal science education will cease following the Junior Cycle as well as those who will continue with science to the senior cycle and beyond.

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[1] Royal Irish Academy submission to the NCCA, January 2014, p.1, accessed online at http://www.ria.ie/about/our-work/policy/academy-advice-papers-.aspx

Current teaching of STEM subjects

Ireland's current teaching of STEM subjects is predominantly based on rote learning, rather than the ability to problem solve. An inquiry-based[2] approach to learning for much of the STEM curricula would provide students with the skills to develop hypotheses, theories and then understanding, based on their own observations, getting them thinking creatively and developing critical thinking skills. This would apply to all of the STEM subjects. All current thinking, international best practice and many commissioned reports point in this direction if Ireland is to continue to develop a knowledge-based society. This opinion was clearly evident during the Dialogue meeting hosted by the Academy in November 2013 and again in the STEM Review Group's Townhall in April 2014, and echoes similar findings from international studies (see for example, ICSU, 2010; Schaefer, 2010), as well as from Ireland (Eivers & Clerkin, 2013; Murphy, 2013b).

We are best equipped to develop our critical thinking skills during the formative years when we are at school. Initial teacher education (ITE) and continuous professional development (CPD) programmes should continue to adapt and develop their courses so that teachers will have the competence, confidence and motivation to adopt more inquiry-based approaches to teaching science and mathematics. All of these facets, working together, are needed to achieve the outcome of a better STEM-educated population.

The challenges in STEM education

The challenges include:

- a gradual implementation of, and full transition to, a new way of teaching;
- shortening the curriculum to make room for a more in-depth form of engagement with students, a richer student experience and alternative forms of assessment, so that students have more opportunities to apply and develop their scientific skills;
- ways of assessing the application and development of students' skills as well as their conceptual knowledge, which will require more feedback from teachers to students;
- cost and investment.

While this is clearly the way forward, it cannot be achieved overnight and requires gently moving our entire cohort of those teaching STEM subjects towards being comfortable using a problem and inquiry based approach, even when they themselves were not taught in this manner. Notwithstanding the challenges listed above, it is the view of the working group that significant progress could be made within the next 5 years, with regular monitoring of this progress, on a three-year (or shorter) cycle.

STEM teachers graduating in the future can easily be educated in these new pedagogical approaches. At present, teacher education colleges are ready and equipped to switch to this approach, and many have developed inquiry-based approaches for the past decade. Teachers already at the chalk face may have to be taught how to facilitate the implementation of curricula in a problem-based and inquiry-based way, because the majority of them were not educated in that way. CPD for both primary and post-primary teachers and the skills to assess student work and performance differently are thus required.

[2] The ALLEA Working Group Science Education defines inquiry based science education (IBSE) as comprising of "experiences that enable students to develop an understanding about the scientific aspects of the world around through the development and use inquiry skills." (Harlen, Allende 2006).

Regulation of STEM Teaching

Moving the entire STEM teaching profession in a different direction requires persuasion and gentle but firm nudging, and we believe it also requires regulation. This will have implications for the Teaching Council, which should be given the responsibility for recognising and registering discipline-specific teaching accreditation in the STEM area.

Membership of many of Ireland's professions and the licence to practise in those professions are now regulated, and for some, maintaining such a licence to practise requires continuous up-skilling, as demonstrated by certified CPD achievements. The Medical Council is one example where a discipline-specific qualification and CPD 'points' are required for continued registration, and similar regulation applies to STEM teaching elsewhere.

- In Scotland, teachers of STEM subjects must be registered with the General Teaching Council Scotland (GTCS), which stipulates that from 2014 onwards for all senior phase qualification courses (i.e. National 4/5, Higher and Advanced Higher), teaching is to be done by those who are qualified in the subject (i.e. physics, chemistry and biology).
- In Finland, to be a qualified subject teacher in an upper secondary school, a person must have completed a higher University degree (i.e. a Master's degree) and have qualifications in pedagogical studies as well as in the subject matter being taught. We are not recommending this at this time as we believe CPD for existing STEM teachers will suffice.
- In France, at the secondary education level, those who wish to be teachers must pass the *concours*, a national examination that covers the subject the student wishes to teach and also includes a strong element of Mathematics.

Resources for STEM teaching

On the up-side, there are some great examples of resources in Ireland that can help support inquiry-based learning – the Science Gallery, the Annual BT Young Scientist and Technology Exhibition (in which more than 50% of our schools already participate), Exploration Station at the National Interactive Science Centre scheduled to open in Summer 2016, and the emergence of activities such as CoderDojo and SciFest. Industry can also contribute to STEM education initiatives, and many companies are willing or already active in this area. Transition year in schools is a great opportunity for fostering inquiry-based learning, and as many schools struggle to fill the curriculum for transition year students, this is an opportunity that should be grasped.

One downside of all these current initiatives is that they could be better coordinated. At present, some students receive a very positive range of inputs into their STEM education while others receive little or no exposure either to inquiry based approaches in the classroom or through non-formal supports e.g. scientists visiting schools etc. We encourage a better coordination of these resources, which could be pooled at a national level to even out what is currently a very mixed student experience.

Higher Education Institutions (HEIs), in combination with the network of Education Centres (originally Teachers' Centres), may be the platform to deliver STEM education CPD in order to further

professionalise STEM education. Many HEIs already have centres of expertise in education and learning, and the remit of the Education Centres is to organise the local delivery of national programmes of teacher professional development on behalf of the Department of Education and Skills. The combination of these two components would seem to afford the best opportunity for moving STEM education in the desired direction.

There are parallels here with the professionalisation of nursing in Ireland that happened a decade ago, when many HEIs rapidly rolled out degrees in Nursing. While that activity was expensive, the cost of CPD for STEM education could be reduced using online tools and MOOCs technologies that are becoming more mainstream. Combining online with face-to-face interaction for blended learning will help to reduce social cost and disruption to teaching activities by allowing flexible learning, which is to the advantage of both students and teachers. The Teaching Council will have an opportunity to redefine its role by overseeing the accreditation and quality of CPD in STEM education.

Additional Information and References

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