

Science Teacher Education in Scotland

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Background

This section gives the context for teaching in Scotland from the introduction of Curriculum for Excellence (CfE) (The Curriculum Review Group, 2004) until today. The introduction of CfE, which deals with education for ages 3 – 18, resulted in big changes in Scottish education. CfE is the responsibility of Education Scotland which is a Scottish Government executive agency. CfE defines the curriculum as a series of broad Experiences and Outcomes (Es&Os) and leaves the implementation of the Es&Os to the professional judgement of teachers (Education Scotland, 2009). The Es&Os cover the Broad General Education (BGE) phase of the curriculum from ages 3 – 15. Examination courses in the Senior Phase are the responsibility of the Scottish Qualifications Authority (SQA) which publishes details of the new CfE National Qualifications for the National 4 and 5, Higher and Advanced Higher courses (equivalent to GCSE, AS-Level and A-Level courses.) The SQA is “sponsored by the Scottish Government’s Learning Directorate” (<http://www.sqa.org.uk/sqa/5656.html>) but is an executive non-departmental public body which is independent of the Government.

Like other countries, the results of the international PISA¹ studies are important to Scotland. Pleasure at the results in 2009 (Cooke & Bejtka, 2010) turned to disappointment with the 2015 results (National Foundation for Educational Research, 2016). Scotland took part in the TIMMS studies in 2007, but withdrew from subsequent studies because of disappointing results (Learned Societies' Group, 2017). The disappointing results in international studies of pupil achievement, including science, and also in national studies about literacy and numeracy (Scottish Government, 2015b, 2016c) are part of the context for the Scottish Attainment Challenge (Scottish Government, 2015a).

The Scottish Attainment Challenge is part of the commitment by the Scottish Government to equity and inclusion by closing the gap between the highest and lowest attaining pupils which is closely correlated with poverty (Scottish Government, 2015a). The Attainment Challenge is supported by the National Improvement Framework which sets out the plan to close the attainment gap (Scottish Government, 2016a). All teaching and teacher education in Scotland **should** be seen in the light of the Attainment Challenge.

The introduction of CfE, Scotland’s poor showing in international comparison tests and the National Improvement Framework have all influenced the thinking of the new Secretary of State for Education (John Swinney) who was appointed after the Scottish Election in 2016. Mr Swinney directed both Education Scotland and SQA to make changes to CfE and the National Qualifications respectively. As a result, Education Scotland introduced benchmarks to exemplify what children should be able to demonstrate for each of the Es&Os. Separately, the SQA will phase out internal

¹ I’m assuming that anybody reading this will know about PISA, TIMMS, STEM etc.

assessment for National Qualifications over the next few years with the introduction of longer examination papers which will ask questions about a broader range of the course content.

Overall, the educational landscape in Scotland has changed significantly since 2000. However, one thing which has remained constant is the Scottish Government's desire to encourage more pupils to study STEM subjects and move into STEM-related careers. The Scottish Government appointed a Science and Engineering Education Advisory Group (SEEAG) which produced reports about Excellence in Science Education (SEEAG, 2011) and supporting Scotland's STEM culture (SEEAG, 2012). The later report expressed concerns about attracting high quality graduates to become STEM teachers (SEEAG, 2012). Since then the Scottish Government appointed an independent advisory group - the Science, Technology, Engineering and Mathematics Education Committee (STEMEC) – to take forward the work of SEEAG. As a result, STEMEC published a report last year which made a number of recommendations about how to develop STEM and STEM teaching in Scotland (STEMEC, 2016). Following the STEMEC Report, the Scottish Government held a consultation (which closed about the end of January) for comments about the strategy for STEM Education and Training (Scottish Government, 2016b).

Several bodies in Scotland, including ASE, have tried to influence Government policy about STEM education, either via the Science Strategy consultation or by responding to other consultations or calls. For example, the SQA recently published a consultation document about data in science examinations (SQA, 2015) which received a robust response from The Learned Societies' Group on STEM Education (2015). The Learned Societies' Group is organised by the Royal Society of Edinburgh and includes organisations such as the IoP and ASE and is actively engaged in debates about STEM education in Scotland. Last year it provided a briefing paper for the Scottish Parliament about STEM Education (Learned Societies' Group, 2016a). It also provided two robust responses to the Education Scotland Science Benchmarks consultation (Learned Societies' Group, 2016b, 2016c). At the beginning of this year, it also provided a response to consultation about the draft STEM Strategy for Education and Training (Learned Societies' Group, 2017).

Overall, there is lively debate within Scotland about all aspects of STEM education which informs the context for any discussion about STEM education in Scotland. The next section will discuss teacher education in Scotland which is still reverberating to the implications of a 2010 review of teacher education (Donaldson, 2010). This section will also explore the role of STEM subjects in initial teacher education. The final section discusses the role of CPD in science education in Scotland.

Teacher Education in Scotland

Teacher education in Scotland is funded by the Scottish Government which decides on the number of student teachers places available each year. Teacher education is still heavily influenced by the recommendations contained in the Donaldson Review of Teacher Education: Teaching Scotland's Future (Donaldson, 2010). The Donaldson Review recommended closer partnership between Teacher Education Institutions (TEIs) and the Scottish Local Authorities (LAs) so that the LAs have a greater role in teacher education. More recently, the Scottish Government's unhappiness about the way in which teacher education is concentrated in the Central Belt is leading to the development of alternative pathways into teaching – with each TEI developing its own model (GTCS, 2016).

The body responsible for teacher education in Scotland is not the Scottish Government, but the independent General Teaching Council for Scotland (GTCS) which is funded by contributions from teachers. The GTCS is one of the oldest Teaching Councils in the world and the first to become independent of Government (GTCS, 2012). The GTCS sets the standards for the teaching profession, including the entry qualifications (GTCS, 2013b). The GTCS is not directly involved in teacher education, but offers guidelines for initial teacher education (GTCS, 2013a). The GTCS sets the standards for Provisional Registration for probationer teachers (equivalent to NQTs in England) and ensures that probationer teachers meet the standards for Full Registration. The GTCS also requires all teachers to go through a five-yearly cycle of Professional Updates to retain their registration. Teachers who qualified in other parts of the United Kingdom or other parts of the world and who wish to teach in Scotland need to register with the GTCS which ensures that their teaching qualifications are at an appropriate level.

Teacher education in Scotland is based in universities, which are referred to more formally as Teacher Education Institutions (TEIs.) One of the major influences on the way in which the TEIs work was the Donaldson Review (Donaldson, 2010, 2014) which proposed major changes to teacher education. One of the main recommendations was a partnership model between the TEIs and the Local Authorities which gives the Local Authorities and schools more input into the practicum element of Teacher Education. The TEIs prepare student teachers by running modules about general education as well as the pedagogy of particular subjects. School placements are now allocated by the GTCS in partnership with the Local Authorities. Joint responsibility for student teachers on placements is shared between individual TEIs and the placement schools.

The two main routes into teaching are the four-year undergraduate BA² route (mainly) for Primary Education and the one-year postgraduate Professional Graduate Diploma in Education (PGDE) route for primary and secondary teaching. The difference between the BA Primary route and the earlier Bachelor of Education (BEd) route, which concentrated on primary education, is that the BA route includes a wide range of university subjects in first year as well as education classes and increases the proportion of education classes each year so that the BA students receive a broader education than the traditional BEd route. The difference between the current PGDE courses and the earlier PGCE (Postgraduate Certificate of Education) courses, is that unlike the PGCE courses, the PGDE courses now offer Masters level credits (SCQF Level 11 (SCQF, 2012)³) for academic work. School placement credits are still at Senior Honours Level (SCQF Level 10).

There are also a number of other undergraduate routes into teaching, mainly for students studying STEM subjects. These models are variously called Concurrent or Joint Honours degrees when undergraduates study their main subject but also complete the one-year PGDE course over third and fourth years. Another model adapts the five-year undergraduate Master of Science in Chemistry route so that the students complete the PGDE course as the fourth year of their degree along with some chemistry credits and then return to Masters level study in their fifth year to complete, for example, a Master of Chemistry (MChem) with Teaching degree at the University of Strathclyde.

² Honours degrees in Scotland are studied over four years.

³ The Scottish Curriculum and Qualifications Framework (SCQF) is a unified framework for Scottish Qualifications. The National 5 examinations, equivalent to GCSEs are at Level 5; doctoral work is at Level 12.

As a result of the Donaldson Review (Donaldson, 2010) and following later consultation, the Scottish Government concluded that the current routes into teaching were too restrictive, and too focused on the Scottish Central Belt. As a result, a number of new routes into teaching have been proposed (GTCS, 2016). All of the TEIs, even those in the Central Belt, are developing their own models, but most of these models are concentrated on encouraging more teachers into STEM subjects and are still focused on the Central Belt. For example, the University of Stirling is developing a qualification for primary teachers with a focus on STEM subjects and the University of the Highlands and Islands (UHI) has developed a new undergraduate route into teaching for non-traditional applicants based in Perth.

Another of the implications of the Donaldson Review is that the TEIs have entered into partnership agreements with the surrounding Local Authorities. The partnership agreements give schools a larger input into the decisions about student teacher progression on placement. Overall, the Donaldson Review and the current development of a range of alternative routes into teaching will bring about more changes in teacher education in Scotland, but the nature of these changes is still unclear.

Staffing in Schools/Departments/Faculties of Education is the responsibility of the TEIs has changed over the last ten years to reflect the pressure on universities to excel in the Research Excellence Framework (REF). Most staff who taught the pedagogical aspects of primary and secondary subjects used to be experienced school teachers who were appointed as permanent members of staff in the TEIs. As these experienced teacher educators left they were replaced by temporary staff who had also been teachers. In the last three years, posts which have become vacant have been filled by experienced teachers seconded for two years from partnership Local Authorities. The seconded teachers bring a wealth of current classroom experience and enthusiasm to ITE which supplements the depth of knowledge and enthusiasm of experienced teacher educators.

A high proportion of seconded staff presents benefits and challenges to schools and TEIs alike. During the course of a secondment, teachers contribute to the TEIs and also develop their own professional understanding and experience. When the seconded teachers return to schools, they bring this wider experience to schools to the benefit of staff and pupils. However, a high turnover of seconded staff and decreasing numbers of permanent teacher educators reduces the depth of institutional knowledge and understanding about teacher education in the TEIs. The implications of this remain to be seen.

Science Education within ITE

The minimum entry requirements for teaching courses are set by the GTCS, but the TEIs individually determine the suitability of applicants for programmes (GTCS, 2013b). The minimum entry requirements for undergraduate and postgraduate routes into teaching are Higher English or equivalent (equivalent to AS-Level) and National 5 Mathematics (equivalent to GCSE). For entry to a PGDE course, an applicant must also have a degree with a minimum of 80 suitable credits in the subject(s) they wish to teach. (A Scottish Honours degree lasts for four years, with students studying 120 credits each year.)

Secondary Science Teaching

These entry requirements apply to the PGDE courses in Physics with Science, Chemistry with Science and Biology with Science. For example, for the Physics with science PGDE, an applicant with a degree from a UK university with Physics in the title and Higher English would be invited for an interview to determine suitability for the course. Different TEIs take different approaches for applicants with a degree without physics in the title. For example, depending on the TEI, an applicant with an Engineering degree from a UK university could either not be interviewed or could be asked to supply a degree transcript to determine whether or not the degree contained a wide enough range of physics topics to be able to teach the common physics topics in schools. The approach for applicants applying for Biology or Chemistry with Science is broadly similar.

As might be expected, the number of applicants depends on the subject. There are many more applicants than places for Biology courses and Chemistry is also oversubscribed. There is more difficulty attracting applicants for Physics courses than the other sciences. One theory is that this may reflect the ease with which those with a physics degree can find a job outside teaching.

Scottish science teachers are educated as specialists in teaching their subject, but the titles of the science PGDE courses include the phrase 'with Science.' All physics, chemistry and biology teachers in Scotland are qualified to teach General Science in the first three years of secondary school in what is called the Broad General Education (BGE) phase⁴ (Years 8, 9 and 10 in England.) Consequently, student teachers of science also have classes about teaching General Science.

The entry requirement of a degree with enough physics, chemistry or biology to teach means that all student teachers of science are assumed to have a good knowledge of their own subject. If they are unfamiliar with some areas of their main subject, or other science subjects, we assume that as graduates they will be able to research and understand these new topics. Indeed, Kind (2009) suggests that good student teachers often teach better in a different science discipline *because* they have to do this research and conceptualise the subject in a way which makes it accessible to pupils.

PGDE courses contain general education studies modules as well as specialist subject pedagogy modules. The focus of the science pedagogy modules is not learning about science but learning to teach science. This approach can be conceptualised as developing the student teachers' pedagogical content knowledge (PCK) (Shulman, 1987) about teaching science. In addition to physics, chemistry and biology classes for their own subject, student teachers of science also have 'specialist' General Science classes to consider how to teach the whole range of science in the first three years of secondary school.

An important and enjoyable part of PGDE science courses across Scotland is the two-day, residential Scottish Universities Science School (SUSS.) This is held in January every year for **all** the student teachers of science in Scotland - approximately 220 students. As well as providing an insight into different aspects of teaching science, SUSS provides opportunities for the student teachers to network with the representatives of RSC, IoP etc. and future colleagues from across Scotland.

⁴ Scottish pupils spend seven years in primary school and up to six years in secondary school.

Primary Science Teaching

The mathematics and English entry requirements for undergraduate primary teaching degrees and the Primary PGDE are the same as for the Secondary PGDE. In addition, applicants for the PGDE Primary Teaching course must have a degree or equivalent. Therefore applicants need not have studied science since they made their subject choices in secondary school. This applies to both the undergraduate and the postgraduate routes. There is often little opportunity for primary student teachers to study much science in their courses.

The amount of science studied by primary teachers varies among the TEIs, in part because primary student teachers are required to study a wide range of modules. These range from educational modules to the necessary focus on literacy and numeracy, and in Scotland, Health and Wellbeing. Student teachers also study the wide range of subjects taught in primary schools. As a result, there is little space in the curriculum to study individual school subjects including science. Primary student teachers study some science in all of the TEIs and there are also options to choose to study more science. It would be interesting to know if the student teachers who choose to study more science are doing so because they are confident in their science knowledge and wish to develop it or if they are studying science because they lack confidence in their science knowledge and wish to develop it.

The lack of time to study science content and the pedagogy of science teaching in the TEIs can reduce teachers' confidence to teach science. This lack of confidence can also make it difficult for primary teachers to develop their self-efficacy about learning and then teaching science. As a result, there can be a reluctance to teach science in the primary school. One of the ways in which the TEIs are addressing these problems is by helping primary student teachers to develop their confidence and self-efficacy to learn about science in order to teach science well (van Aalderen-Smeets et al, 2012).

Support for Teaching Science in Scotland

A high level of support for primary and secondary science teaching is provided by the Scottish Schools Equipment Research Centre or SSERC. SSERC is funded by all 32 Scottish Local Authorities. As a result of its Local Authority funding, SSERC's advice has been available to all teachers in Scotland free of charge. It consistently provides high quality and impartial advice about teaching science to primary and secondary teachers in Scotland. In addition, the SSERC website provides free access to high quality teaching materials directly linked to the Scottish curriculum (SSERC, 2017). SSERC also provides Career Long Professional Development (CLPD) in science for Primary and Secondary teachers. CLPD links to the GTCS Professional Update process, which is a five-yearly reaccreditation process for teachers (GTCS, 2017). SSERC is currently running a programme of CPD for science based around a cluster of primary schools and their associated secondary schools. The pilot scheme was very positively evaluated (Lowden, Hall, & Friel, 2015) and is now being rolled out to the other Scottish LAs.

Professional bodies such as the IoP, RSC and ASE provide high quality CPD for primary and secondary science teachers in a range of formats such as conferences, summer schools and twilight sessions. The SQA also runs update courses for teachers as the result of changes to the curriculum. More widely, organisations such as the Glasgow Science Centre and Our Dynamic Earth in Edinburgh offer interactive experiences for teachers and pupils and also offer CPD for teachers.

The option for student teachers to gain 80 Masters credits as parts of the PGDE courses has meant that the TEIs now encourage probationer teachers (NQTs) to study for an additional 40 Masters credits in their Induction Year⁵. Completing 120 credits of Masters study allows the teachers to progress to a dissertation to complete a Masters degree in Education. As well as traditional Masters modules in education studies, some of the TEIs are developing focused STEM modules to allow teachers to specialise in STEM education.

Conclusion

STEM education in Scotland is in a state of flux with the introduction of CfE (Science) Benchmarks for younger pupils and changes to the structure and content of SQA examination courses for older pupils. The Scottish Government has a number of initiatives to make a career in STEM teaching more attractive which is resulting in changes to the ways in which the TEIs recruit and teach STEM subjects. One of the challenges for secondary ITE is consistently attracting enough graduates, especially in Physics. ITE also has a role to play in increasing the confidence and self-efficacy of primary teachers to teach science. Initiatives such as SSERC's Cluster Programme provide CPD for some primary and secondary teachers but the challenge is to roll these out to all teachers who could benefit from them. We live in interesting times.

⁵ All student teachers in Scotland successfully completing a PGDE course can opt in to an Induction Year which allows them to reach the GTCS Standard for Full Registration.

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