Estyn evidence to the Enterprise and Learning Committee

Science, Technology, Engineering and Mathematics (STEM) skills

1. Thank you for the opportunity to submit evidence to this inquiry. We welcome the inquiry as it is both timely and important. STEM skills are crucial to the education of the young people of Wales and to the economic wellbeing of the country.

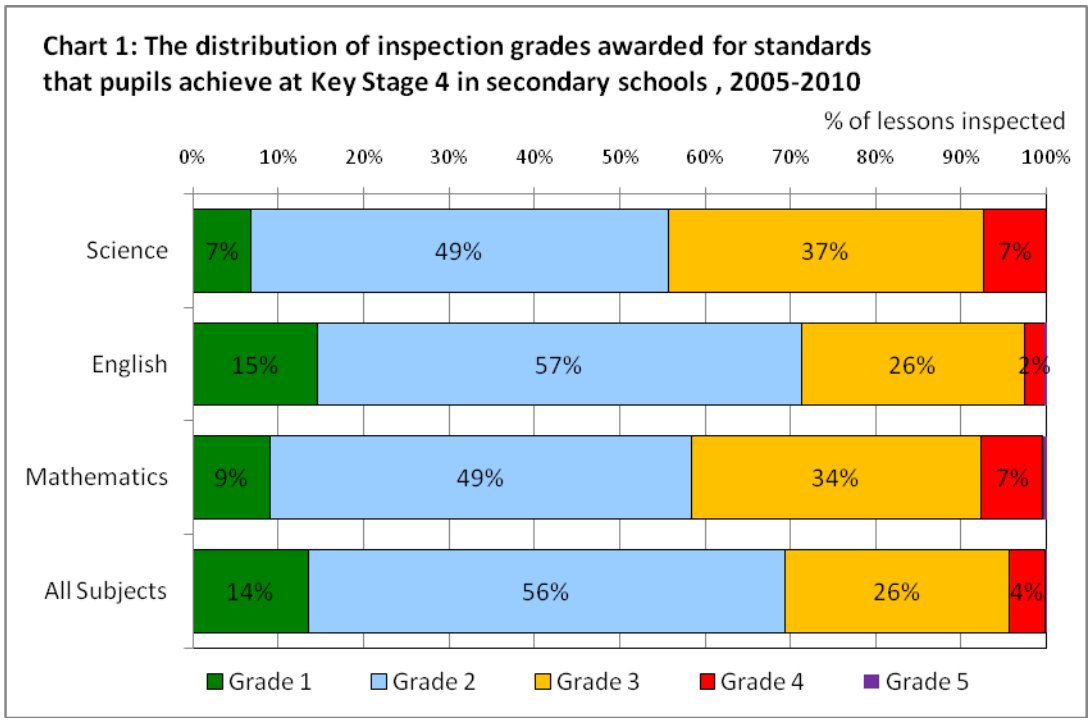
2. In May 2008, Estyn published a report on science education for 14-19 learners. The evidence below updates that report and extends it to include mathematics and engineering. The main findings and recommendations of the 2008 report are still valid. It concluded that there was a need to develop a science education strategy for Wales that would provide a significant impetus to improving standards and the quality of teaching and leadership. It is still our view that a national education strategy, expanded to encompass all STEM subjects, is needed as a matter of urgency. Other recommendations included the need for more subject-specific in-service training for teachers and leaders and the better promotion of applied and vocational courses. I attach the report which provides further details on these matters.

Standards

3. Standards[1], judged in inspections of secondary schools, are significantly lower in science and mathematics than in other subjects. This has been a consistent trend each year in the last inspection cycle, during which all schools in Wales were inspected, and stretches back further into the previous cycle. The proportion of lessons in which learners achieve well or better in science and mathematics is well below the average for all subjects and compares poorly with other subjects, for example with English.

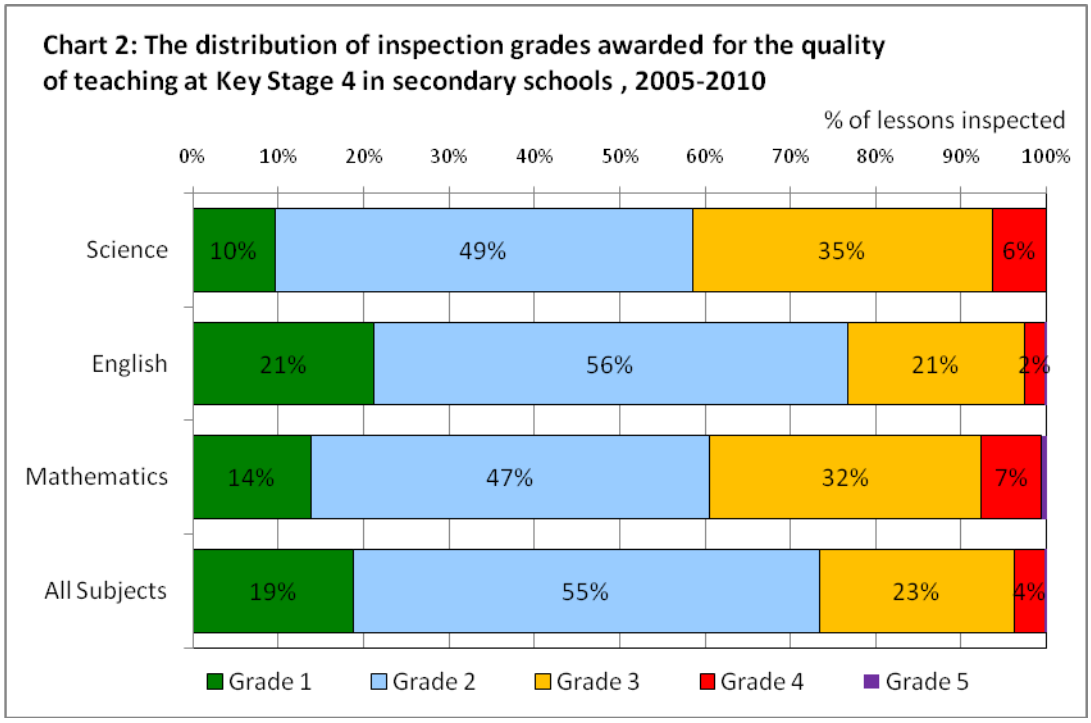
4. This pattern is the case at key stage 4 (for 14 to 16 year-olds), as shown in chart 1 below, and is also true in key stage 3 (11 to 14 year-olds) and in the sixth form. The picture has been more mixed in primary schools, where during the initial part of the last cycle of inspections, standards in science and mathematics were found to be as good as or better than other subjects, but more recently there has been a decline in standards in science and mathematics relative to other subjects at the primary age range also.

[1] By standards we mean learner outcomes in terms of recall of basic facts, understanding and application of concepts, and proficiency in investigative skills as set out in inspection, curriculum and examination documents.



Teaching

5. The quality of teaching is also poorer in science and mathematics than in other subjects. In particular, science and mathematics teaching has fewer outstanding features (grade 1) than in English or the average for all subjects, for example as shown in chart 2 below for key stage 4.



Leadership of science and mathematics departments

6. Science and mathematics departments are less well lead than other subject departments in secondary schools. Inspectors judged the leadership and management to be good or better (grade 1 or 2) in two-thirds of secondary school mathematics departments and in about one in six science departments. There are therefore significant shortcomings in the leadership of least a third of these departments.

Chart 3: Leadership and management of subject departments

Proportion of key questions 5, 6 and 7 graded 1 or 2	Science	Mathematics	English	All subjects
2005 - 2010	58%	66%	82%	74%

7. Science departments teach biology, chemistry and physics, and heads of science find it especially difficult to provide strong leadership to improve standards across all three subjects, as their pedagogic knowledge is usually limited to one subject. Training courses for heads of science focus on administrative tasks and do not address subject-specific leadership skills that will encourage innovative and effective teaching methods and curriculum planning.

Engineering

8. Nearly all further-education colleges in Wales offer engineering. Courses in mechanical, motor vehicle, electronics, manufacture, fabrication and welding, marine, maintenance, environmental or aerospace engineering usually represent a large proportion of the provision of colleges. General courses at level 1 or 2 are offered, followed by more specialist programmes at higher levels, largely dependent on the nature of local industry. On the other hand, engineering provision in schools is not extensive, as schools lack teachers with specialist knowledge or appropriate equipment. Where schools offer engineering it has been mostly in partnership with further education colleges. The most popular programmes for 14 to 16 year-olds are motor vehicle courses. These programmes have done much to encourage vocationally-focused pupils to take up engineering-related courses at higher levels.

9. Many engineering departments in further-education colleges and in work-based learning providers are very effective and most attained high grades during inspection. However, too many less-able learners, often with literacy and

numeracy levels below level 1 and a background of underachievement, are directed to take up demanding engineering college programmes, and often struggle with the mathematics content of the programmes. With improving school-college link arrangements this problem is beginning to be addressed. Also, double award GCSE science is considered by further education teachers not to provide enough physical science background to prepare learners for engineering sciences at post 16.

10. Estyn is currently undertaking survey work as part of its annual Ministerial remit from the Welsh Assembly Government on the current engineering provision in further-education colleges and work-based learning providers. The report will be published in the spring of 2011.

Examination outcomes and participation

11. International studies such as that by OEDC's Programme for International Student Assessment (PISA) suggest that Wales' performance in science and mathematics is near to the norm of other countries.

12. Examination results are partly norm-referenced and so provide limited guidance on outcomes at a national level. The proportion of pupils gaining an A* to C GCSE grade or equivalent in science has seen a marked improvement between 2004 and 2010. This may be due to the recent inclusion of more non-GCSE qualifications in the definition of this statistic and an increase in the availability and take-up of such qualifications. The proportion of pupils gaining grades A* to C in mathematics has also improved gradually since 2004, but at a slower rate than in science.

13. In 2008, the Royal Society published 'Science and mathematics education 14-19 – a state of the nation report' which showed, among other findings, that the proportion of learners taking biology, chemistry, physics and mathematics at a higher level in Wales was significantly below that of the other home countries (Advanced level in Wales, England and Northern Ireland and the Higher qualification in Scotland) – see chart 4 below for physics for example. This indicator is a proxy for measuring participation in post-16 science and mathematics education. The downward trend in take up of physical science A levels in Wales has been halted recently, as shown in chart 5 below. This chart also illustrates the well-known imbalances in the number of boys and girls studying biology and physics.

Chart 4: Entries to physics A-level across England, Northern Ireland and Wales as a percentage of the 17-year-old population in these nations (2000–2007)

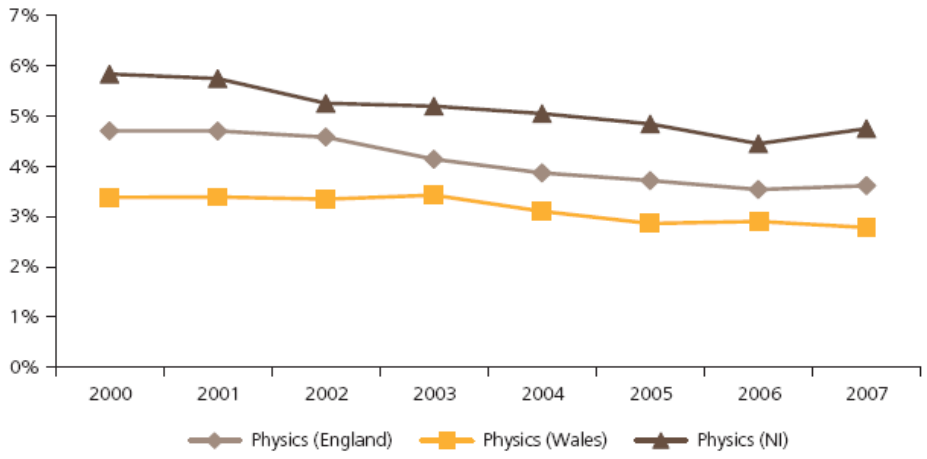


Chart 5: Take-up of A level biology, chemistry and physics (number of entries)

	2006/07	2007/08	2008/09
Pupils			
Biology	2,149	2,188	2,173
Chemistry	1,620	1,774	1,794
Physics	1,092	1,098	1,236
Boys			
Biology	918	950	947
Chemistry	817	914	975
Physics	879	852	987
Girls			
Biology	1,231	1,238	1,226
Chemistry	803	860	819
Physics	213	246	249

Recruitment and in-service training of STEM teachers

14. About the same number of biology teachers gain qualified teacher status in Wales as chemistry and physics teachers put together. Because the background of most science teachers is in biology, specialist physics (and to a lesser extent chemistry) teachers tend predominantly to teach GCSE and A-level classes. As a result, a disproportionate amount of teaching at key stage 3 is delivered by teachers with

only a biology background. This means that their pupils may not gain a sound skill base in physics or be sufficiently motivated to take up study of the physical sciences at a higher level. Neither is there enough in-service training for science teachers who need to develop their subject knowledge of physics and how best to teach physics.

15. The number of students able to teach in Welsh who gain qualified teacher status in mathematics or science is very low. Fewer than 15% of newly qualified physics teachers over each of the last four years (often considerably fewer) are capable of teaching in Welsh, while 25% of secondary schools in Wales are Welsh-medium.

16. Initial teacher training numbers for mathematics decreased during the period 2005 and 2008.

17. The majority of engineering teachers in further-education colleges and in work-based learning providers have significant industrial experience and expertise. Colleges have effective in-service training arrangements that require new engineering teachers to gain teaching qualifications. However, arrangements for engineering staff to maintain their industrial currency are generally underdeveloped, despite links with engineering employers being strong in many colleges.

Summary

- Standards in science and mathematics are lower than in other subjects.
- Teaching in science and mathematics is poorer than in other subjects.
- Leadership of science and mathematics departments is less effective than in other subjects.
- Participation in science and mathematics post-16 courses is lower in Wales than in the other home countries.
- Engineering is often promoted as a choice for less-able learners.
- Recruitment of physics and chemistry teachers is lower than for biology teachers.
- There is not enough subject-specific in-service training for science teachers or for heads of science departments.