Science Education in Scotland

As I grew up in England, I was not familiar with the Scottish education system. When my oldest child moved on to secondary school in 2015, I was very surprised to find that critical decisions are made so early. In February of S1, pupils make their subject choices for S2 and S3 and are able to drop all bar one science. Bearing in mind that these children can be as young as eleven, I find it astonishing they are expected to make such life-defining choices. It is asking a lot of eleven year olds to choose physics or chemistry when choices such as mountain biking or musical media studies are also available. Children also feel pressure to pick the same subjects as their friends, rather than stand out.

The school my children attend is exceptionally good, but by the end of first year they have had only 28 hours of teaching in each science subject. This is not a sufficient level of science education for the technologically and scientifically complex world we live in.

A further choice is made in February of S3 (at fourteen years) when all science subjects can be dropped before the National 5 exams are taken in S4.

I am very concerned by the structure of science education in Scotland and its effects on our society at a time when global competition and equality are regularly debated.

Global Competitiveness

From a brief survey of English speaking countries, I found that Scottish children have very much more limited science education than anywhere else.

In Australia, all sciences are compulsory up to Grade 10.

In the USA it is impossible to graduate from high school without credits in biological and physical sciences (eg California www.cde.ca.gov/ci/gs/hs/hsgrmin.asp).

Canada has implemented an impressive new curriculum which aims to ensure scientific literacy for every secondary school graduate, with all students studying science at appropriate skill levels. See, for example, the Ontario curriculum, (www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf), which recognises on page 3 that "the notion of thriving in a science-based world applies as much to a small-business person, a lawyer, a construction worker, a car mechanic, or a travel agent as it does to a doctor, engineer, or a research scientist."

Closer to home, in Ireland, all sciences are studied up to fifteen years, whilst in England and Wales, all children are expected to study all three sciences up to GCSE level (approximating to our National 5).

Figure 1 shows that, taking maths as an approximation of cohort size (almost all children take maths GCSE), over 50% of children in England are studying a combined science GCSE (covering all three sciences), with almost an additional 20% taking the three individual science GCSEs.

I was not able to extract from the published data how many Scottish children are studying all three sciences at National 5, but with figure 2 showing that only 20% of girls taking maths National 5 also taking physics, and only 30% of boys also taking biology, it is clearly far fewer than in England. Children in the rest of the UK have a much better general knowledge of science when they leave school.

Our young people are competing for places at university and for jobs against young people from all over the world. Our economy depends on our ability to compete with businesses around the world. Science is recognised as a driver of national economies, and a population with a good general knowledge of science would be a more effective competitor.

Equality

I am concerned with two aspects of equality.

1) The gender divide between sciences is very striking, and is remarkably consistent across the English speaking countries where I could find data. This divide appears when students are given choice in which subjects to study.

   In England, everyone studies all sciences up to age 15/16, so the gender ratios are therefore 50:50 in all sciences at GCSE (see figure 3). At age sixteen, many young people have an idea what they would like to do with their lives. If they want to study medicine, physics or engineering, they can continue the appropriate subject choices for A'levels. It is at A'level that the gender ratios appear (figure 4). At A'level, young women make up 60% of biology candidates, 50% of chemists and 21% of physics candidates.

   In Scotland, however, this gender divide occurs earlier. By National 5, only around 27% of physics candidates are female, and only 34% of biology candidates are male. It seems likely that the numbers of girls studying physics and boys studying biology have already fallen significantly in S2 and S3.

   If, at fifteen, a young woman decides she would like to be an engineer, but she dropped physics at twelve, her career pathway is far more complicated than her equivalent in England.

It would be interesting to see what the equivalent ratios are in other European and, in particular, non-western countries, and how much cultural influences affect this.

These ratios in subject preference across the UK mean that young women are less likely to be qualified to apply to study physics or engineering at university, and potentially interesting and high earning careers in those fields are not accessible.

It is difficult for Physics or Engineering departments at universities to shift their gender ratios in undergraduate cohorts if female applicants are not available because they dropped physics at age sixteen (or twelve, in Scotland).

The low numbers of women graduating in physics and engineering is then reflected in the low number of senior women working in physics or engineering in university departments or companies. It is very important to support those women who do choose to work in these fields, as they are going to remain in the minority for as long as young women continue to other subjects at school.

2) I am more concerned about how early subject choices made by children can affect their chances and opportunities after school.

I have been unable to obtain data relating subject choices at national 5 and Higher to SIMD. I would be interested to see this, as my observations suggest that children from more advantaged families are more likely to choose academic subjects (including taking more than one science) in S2 and S3. These early choices could limit career and continuing education options available to young people after school and only serve to continue existing divisions of equality in society.

Universities are being told to increase the proportion of students they enrol from less advantaged backgrounds. If these children are less likely to be choosing sciences from S2 onwards, they are also less likely to be able to apply to study these subjects at university. If we want a greater diversity of young people to work in science at university and beyond, we need to keep them studying science at school.

It is likely that the male to female ratio among applicants flagged as coming from low SIMD schools is even more skewed towards males than the ratio in other applicants. This would cause a conflict between the desire to improve gender ratios within a cohort and the desire to promote applicants from lower SIMDs.

Conclusion

I think that the most important change that should be made to science in Scotland, would be to increase the level of scientific knowledge within the general population. If all children had to study all sciences up to the age of fifteen or sixteen (as in most other countries), they would be better able to understand and interpret the complex scientific and technological information they receive throughout their lives in whatever career they pursue. The population would then be more competitive in the global market.

If all sciences were compulsory up to age fifteen/sixteen, girls would get a better physics education and boys would understand more biology, keeping their career options open for longer.

Encouraging girls to consider careers in physics and engineering is important, by promoting role models and supporting women already working in the field. I suspect that whatever is done, the gender ratios observed today will only change very gradually, but as long as those women who choose to work in these areas are welcomed and are treated equally, I do not think this is a big problem.

I think it is more important to encourage children from less advantaged backgrounds to study more science subjects for longer. This could potentially expand their future choices in further and higher education as well as career options. A better scientifically educated population would benefit the economy and help drive down inequality in society.

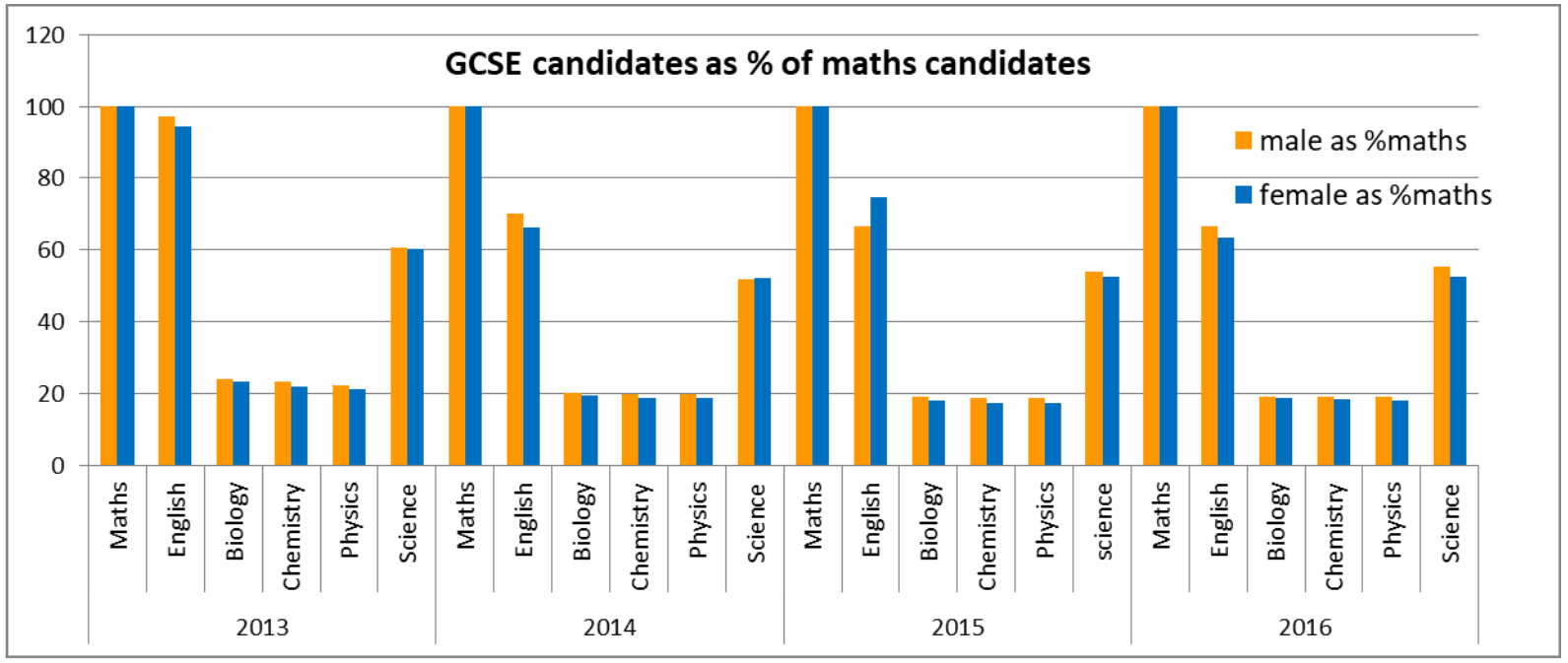
GCSE candidates as % of maths candidates
120
100
80
60
40
20
0
male as %maths
female as %maths
Maths
English
Biology
Chemistry
Physics
Science
Maths
English
Biology
Chemistry
Physics
Science
Maths
English
Biology
Chemistry
Physics
science
Maths
English
Biology
Chemistry
Physics
Science
2013
2014
2015
2016

Figure 1

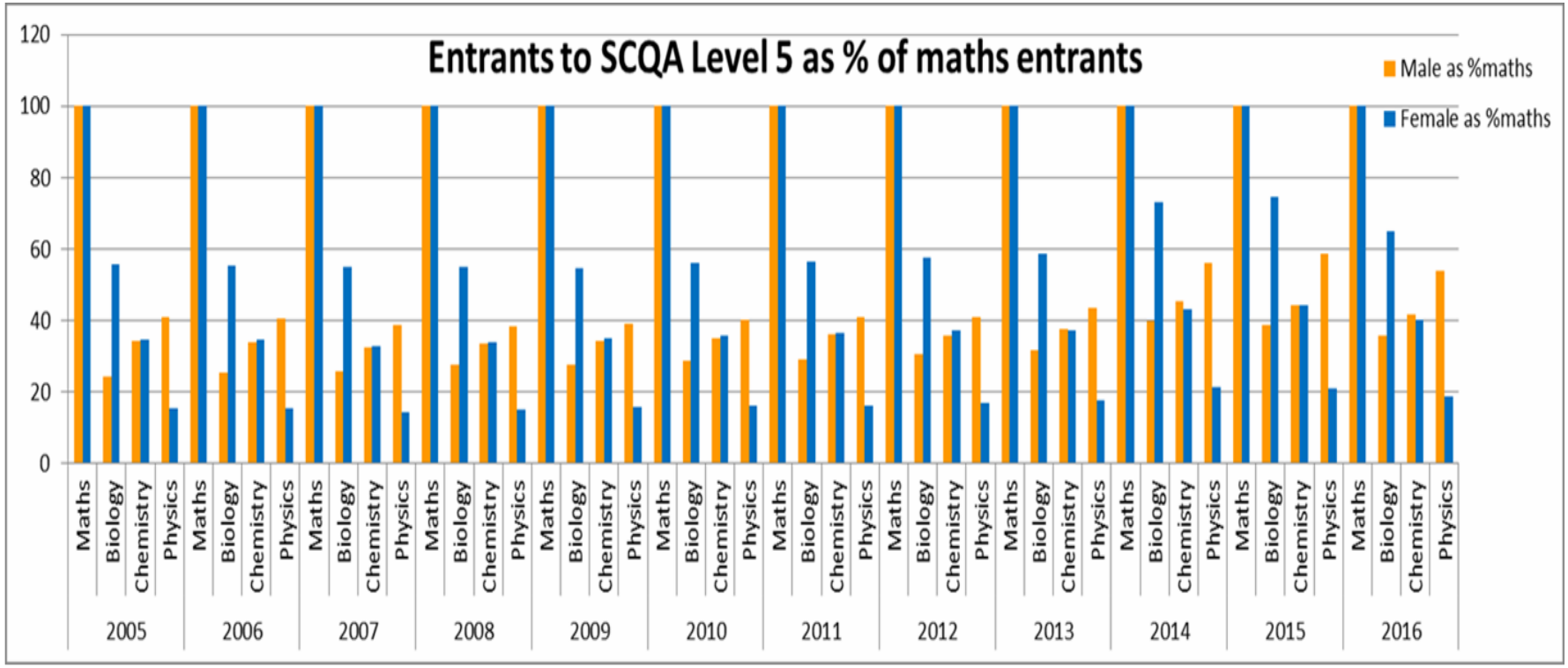
Entrants to SCQA Level 5 as % of maths entrants
Male as %maths
Female as %maths
120
100
80
60
40
20
0
Maths
Biology
Chemistry
Physics
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

Figure 2

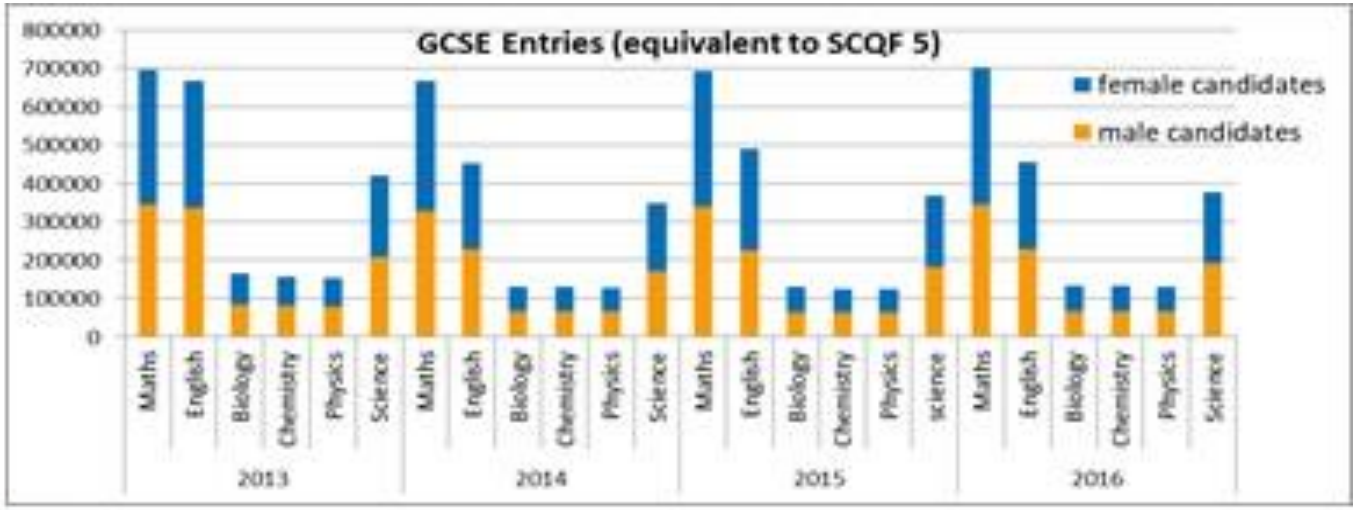

Figure 3

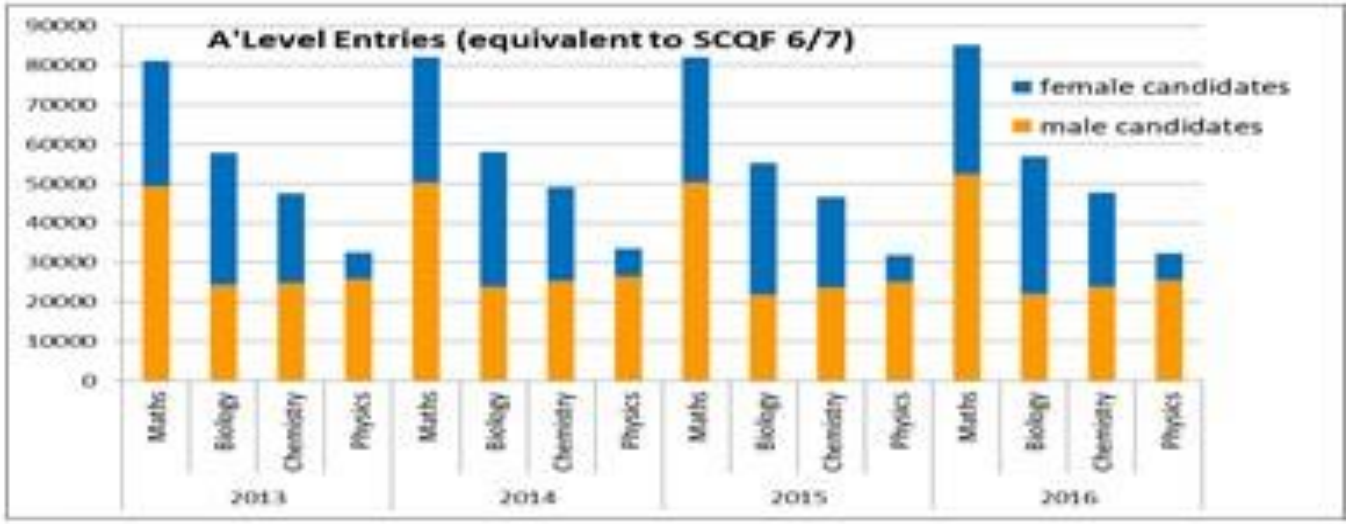

Figure 4

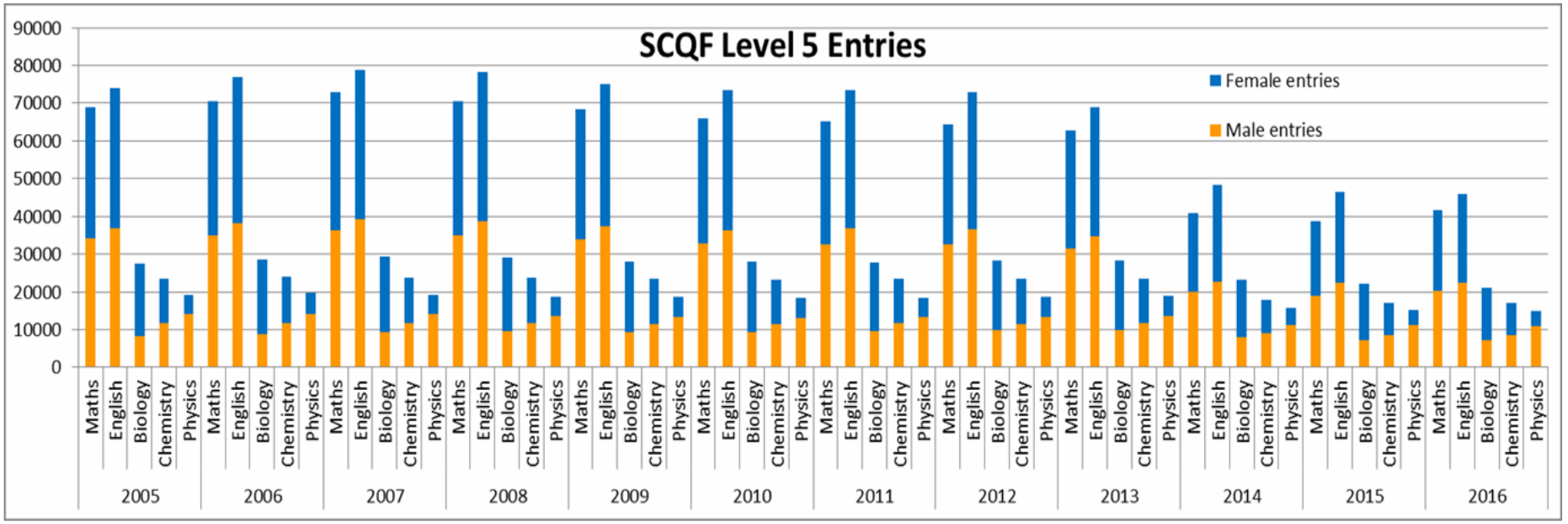
SCQF Level 5 Entries
Female entries
Male entries
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Maths
English
Biology
Chemistry
Physics
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

Figure 5

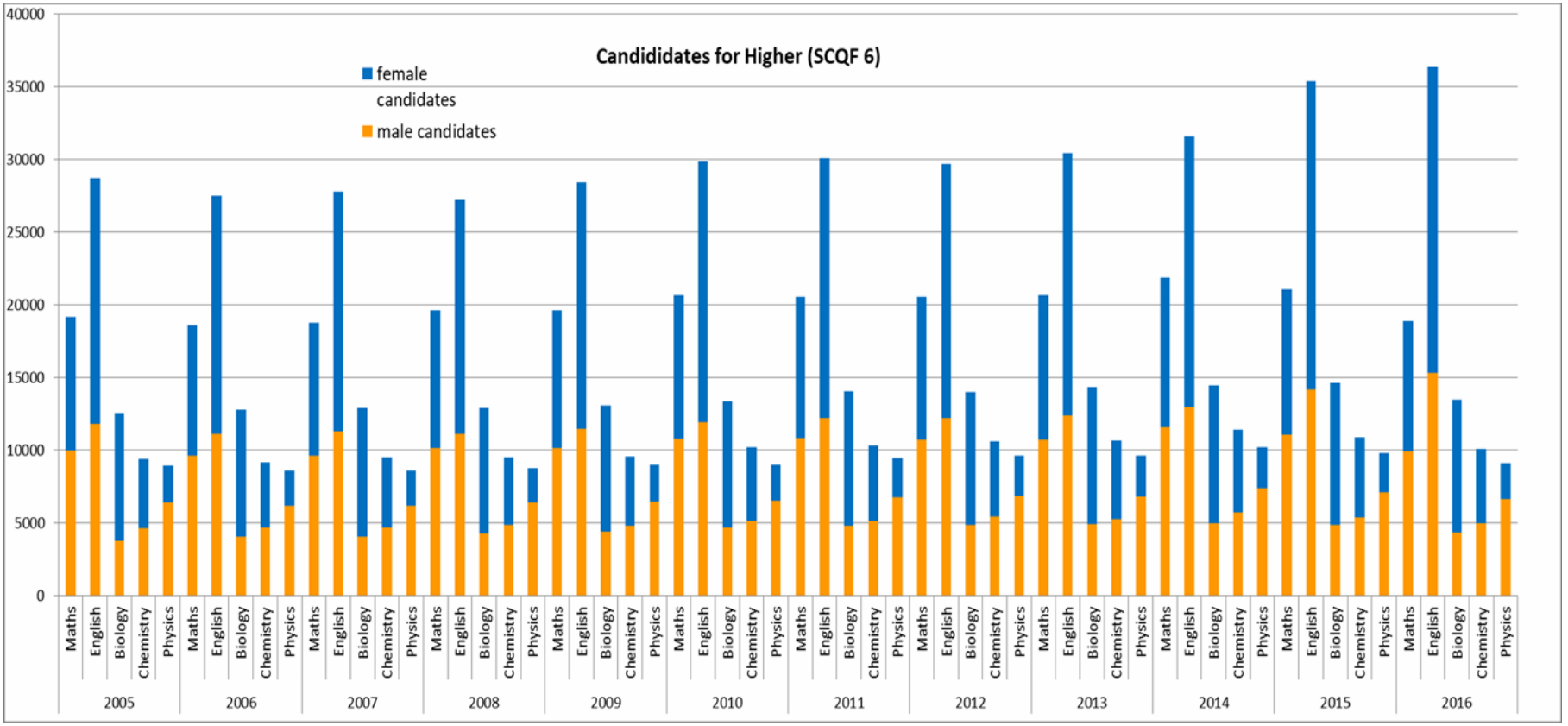
Candididates for Higher (SCQF 6)
female candidates
male candidates
40000
35000
30000
25000
20000
15000
10000
5000
0
Maths
English
Biology
Chemistry
Physics
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

Figure 6