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GENDER AND SCIENCE ENROLMENT AND ATTAINMENT TRENDS IN SCOTLAND

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Abstract:
This paper presents the trend of science enrolment and attainment for the National 5, Higher and Advanced Higher in Scotland. Also, analysis of enrolment and attainment in the core science subjects of biology, chemistry and physics by gender for all three qualifications have been presented. Results in public domain from the Scottish Qualifications Authority (SQA) from 2008 – 2018 (for Higher and Advanced Higher) and 2014 – 2018 (for National 5) were accessed and analyzed. Data were analyzed using simple percentages and t-test for significance, using SPSS. The results show a slight decline in enrolment in the three core science subjects especially for the National 5 and Higher qualifications. An independent sample t-test conducted using SPSS, to compare the mean percentage attainment of boys and girls in Higher biology, physics and chemistry showed a significant difference in the mean percentage physics attainment for boys and girls with $t(20)=9.99$, $p<.05$. The result also shows significant difference in the mean performance by gender in all three subjects at the Advanced Higher level. The study also affirm the gross underrepresentation of girls in physics that has been reported in many countries and that a greater proportion of girls than boys generally attain better grades in science, especially in physics. Finally, the paper calls for a need for further research in investigate for instance, the persistent underrepresentation of girls in physics classrooms despite all efforts to mitigate this imbalance by government and other organizations such as the Institute of Physics (IOP), the Royal Society of Chemistry.

Keywords: science, enrolment, attainment, gender

1. Introduction

Many countries in recent times have expressed concerns about the decline in the interest of most young pupils in choosing Science, Technology, Engineering and Mathematics

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(STEM) related subjects after the compulsory years of schooling. This is reasonably informed by the desire of leaders and stakeholders to avail young people the opportunities to have the right exposure to science and its related disciplines not only for growing a scientifically literate society, but also to be trained and equipped with the right STEM skills and knowledge. In Scotland, it is the government's firm belief that children and young people through the learning of science in schools would develop interest in understanding the physical world with investigative and collaborative tasks that ensures the development of creative skills that are needed in most sectors of the modern economy (Education Scotland, 2018).

This study is concerned about the enrolment and attainment of young people who choose to continue with biology, chemistry and physics after the compulsory years of schooling. In Scotland, pupils (15-17-year-old) make choice of subjects in the senior phase of secondary education (S4, S5 and S6) for the National 5, Higher and Advanced Higher respectively. In many countries, there is a growing concern about encouraging young people to develop interest in the study of science subjects. To match this desire, efforts are doubled to make the teaching and learning of school science interesting and engaging for young people with the training and retraining of science teachers in research tested technique of teaching and transforming how sciences are taught in schools. Despite these endeavors, evidence in literature suggests that there is a general decline in science enrolment when pupils make choices of which subjects to study after the compulsory years of schooling. The problem of relatively fewer students choosing science and physics in particular after the post-compulsory secondary classes has been reported in developed countries like the United States, Canada, England, Wales and Australia (see Osborne, Simon and Collins, 2003; Garg and Gupta, 2003; Semela, 2010; Bennett, Hampden-Thompson & Lubben, 2013; Mujtaba & Reiss, 2013; Kennedy, Lyons, and Quinn, 2014). Osborne, *et al.,* (2003:1050) for instance reported 'the stark nature of the decline in the numbers choosing to do three sciences at 16 for A-level, at the point of choice' in England and Wales.

Apart from the problem of low or decline in science enrolment at the high school level, there is also a concern about the levels of attainment in science subjects. For instance, Osborne, *et al.,* (2003) reported that in England and Wales physics and chemistry were found to be two of the least popular subjects among post-14 pupils and that 'physics has been the subject of a continuing 15-year decline in numbers enrolling and passing' (p. 1058).

Another factor that has been highly debated is that of gender, with boys dominating in the physical sciences while the girls dominate in biological sciences (Barnes, McInerney and Marsh, 2005). Henriksen (2015) reported that in Norway, about a third of students who choose physics in the upper secondary school, choose to discontinue with the subject at the next level and that "*girls are over represented among the 'leavers'*" (p.5). Similarly some have , also reported that males have more positive attitude towards science with greater levels of participating in science related extracurricular activities than females (see Francis & Greer, 1999; Breakwell & Beardsell, 1992; Tripney, Newman, Bangpan, Niza, MacKintosh and Sinclair, 2010; Buccheri, Gurber and

Bruhwiler, 2011). On the contrast, others have argued that gender difference does not affect students' science uptake (see Ormerod, 1975; Stables, 1990). According to Perera & Velummayilum (2008), "*masculinity is characterized traditionally as dominance and competitiveness, while, in contrast, women select careers that have regular hours of work to enable them to fulfil family obligations. It is also suggested that women prefer work that is predictable, subordinate and less financially productive, with low stress levels*" (p.186). Amunga, Amadala & Musera (2011) reported that "*girls are socialized into characteristics of dependence, nurturance and passivity*" and "*therefore develop a set of attitudes and beliefs that do not promote high levels of attainment and participation in science*" (p.234). Research has shown that females have more negative attitude toward science and perceive science subjects to be more useful to boys (Osborne, Simon & Collins, 2003; Amunga, Amadala & Musera, 2011). However, some have argued that choices of subjects to study are more explained by students' beliefs and attitudes rather than by their gender or background (Mujtaba, Sheldrake, Reiss and Simon, 2018). Stake holders, education authorities and government and non-governmental agencies in many countries have committed substantial funds and resources to eliminate these observed gender related differences in subject choices, especially in the sciences, with little success (Barnes, *et al.,* 2005)

2. Aims of the study

The general aim of this study is to investigate the enrolment and attainment trends in biology, chemistry and physics among high school students in Scotland. This is necessitated by the scarce availability of information about the trend of enrolment and attainments of Scottish school leavers in academics literature. Another consideration for this study is the possibility of developing further research following the results of the present study on intervention strategies to enhance science enrolment and attainment and to mitigate gender differences in science classrooms in Scotland.

3. Research Questions

1) What is the trend of biology, chemistry and physics enrolment among high school students in Scotland?
2) How does gender affect the enrolment in biology, chemistry and physics among high school students in Scotland?
3) What is the trend of biology, chemistry and physics attainment among high school students in Scotland?
4) How does gender affect the attainment in biology, chemistry and physics among high school students in Scotland?

4. Methodology

Results of National 5 (2014 -2018), Higher, and Advanced Higher (2008-2018) for biology, chemistry and physics were accessed from the Scottish Qualifications Authority (SQA)

website. These results are in the public domain. For all the qualifications, the percentage of entries (enrolment) for each of the core science subjects relative to the entire cohort has been computed. To investigate the enrolment in terms of gender, the number and percentage of male and female entries relative to the number of entries for the qualification was computed for each year. The science attainment data for each of the qualifications were computed from the number of enrolment for the subjects and qualifications. Means, percentages and simple frequencies have been utilized to analyze data while cluster bar charts are used to present analyzed data.

5. Presentation of Data and Results

5.1 National 5 science enrolment and attainment data

In this paper, the National 5 results for five years (2014-2018) have been computed to investigate trends of general enrolment and attainment for biology, chemistry and physics. The enrolment and attainment data have also been analyzed with respect to gender for each subject. The National 5 qualifications replaced the Standard grade from 2014. The results and charts are presented below.

5.2 National 5 Science Enrolment Data

The enrolment data for biology, chemistry and physics is presented in Table 1.1. Percentage enrolment for each subject relative to the total entry for the examination have been computed and are shown in brackets.

Table 1.1: National 5 Enrolment Trend for biology, chemistry and physics

Years	Total Entries	Biology Entry (%)	Chemistry Entry (%)	Physics Entry (%)
2014	213601	16147 (7.6)	14157 (6.6)	11932 (5.6)
2015	288034	21638 (7.5)	16659 (5.8)	14942 (5.2)
2016	295013	21208 (7.2)	17043 (5.8)	14886 5.0)
2017	293167	21412 (7.3)	16398 (5.6)	14164 (4.8)
2018	281785	20928 (7.4)	15930 (5.7)	13699 (4.9)

(**Source:** SQA Annual Statistics Reports for 2014 – 2018)

The table shows that although the actual number of entries have generally increased from 2014 to 2018 for all three subjects, the percentage enrolment has declined since 2014. Although, not very remarkable, a steady decline in enrolment can be observed from 2014 to 2017 for chemistry and physics, while biology that dropped from 7.6% in 2014 to 7.2% in 2016 appears to be gradually increasing with 7.3% and 7.4% for 2017 and 2018 respectively. Chemistry and physics also made little increases from 5.6% to 5.7% and 4.8% to 4.9% respectively from 2017 to 2018.

The table shows that biology is the most popular science subject chosen by pupils after the compulsory years of schooling for the National 5 qualifications in Scotland. The data also shows that physics is the least chosen science subject by students in the National 5 examinations.

5.3 National 5 biology, chemistry and physics enrolments by gender

The percentage enrolments for boys and girls for all three science subjects is presented as graphs in Figures 1.1a, 1.1b and 1.1c

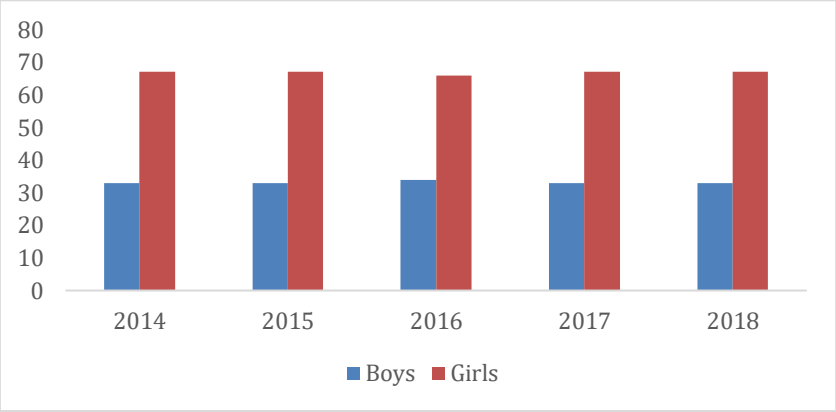

Figure 1.1a: National 5 percentage enrolment in biology by gender

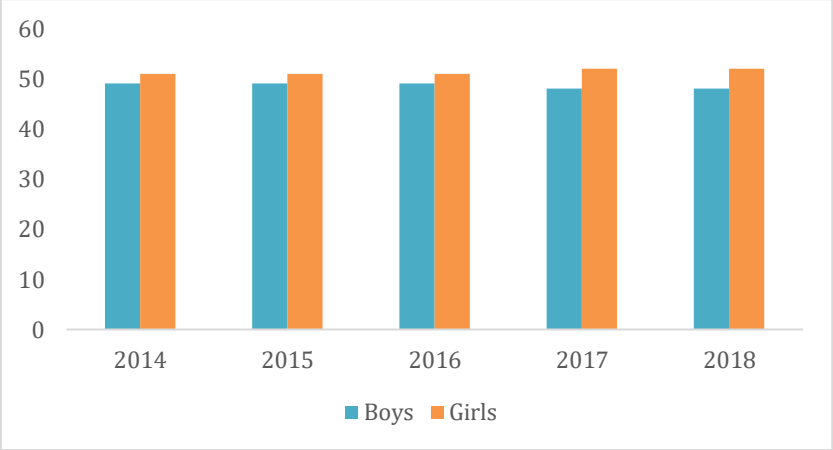

Figure 1.1b: National 5 percentage enrolment in chemistry by gender

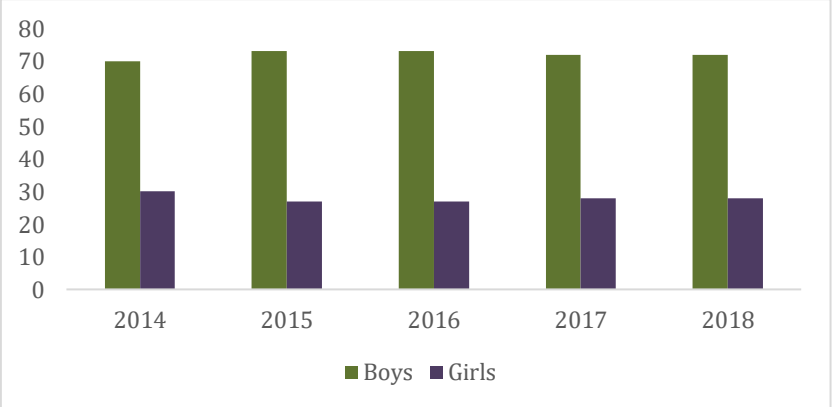

Figure 1.1c: National 5 percentage enrolment in Physics by gender

The data as displayed in Fig. 1.1a, b and c show that more girls enrolled for biology and chemistry than boys for the years under review, while physics is more chosen by boys than girls for the National 5 examinations for all five years under review. The difference in entries in favor of the girls is significantly more in biology (over 30%) than

in chemistry, while for physics, the number of boys is more than double that of the girls. The data in Scottish High schools also shows that for boys, the increasing order of popularity among the school science subjects is biology, chemistry and physics. The trend was reversed for girls with physics, chemistry and biology in order of increasing popularity.

5.4 National 5 Science Attainment in Scotland

The percentage of candidates who attained pass grades A-C for biology, chemistry and physics in the National 5 examinations from 2014 to 2018 is presented in Table 1.2.

Table 1.2: National 5 Attainment (A-C grades) for biology, chemistry and physics (%)

Years	Biology	Chemistry	Physics
2014	65	74	69
2015	70	72	74
2016	73	76	73
2017	71	76	73
2018	73	77	74

Source: SQA Annual Statistics Reports for 2014 – 2018.

The attainment data as shown in Table 1.2 reveals some improvement for biology with attainment rising from 65% in 2014 to 73% in 2016, slightly dropped to 71% in 2017 and improved to 73% in 2018. Chemistry attainment improved to 77% in 2018 from 72% in 2015 after a slight drop of 2% in the previous year. For physics, the A-C grade passes increased from 69% in 2014 to 74% in 2015, dropped to 73% in 2016 and 2017 before climbing by 1% in 2018.

The table shows that apart from 2015 when physics students recorded a higher percentage of A-C grade, the attainment percentage in chemistry is higher than physics and biology for the National 5 examinations. The data also shows that although biology is the most popular science subject among students after the compulsory years of schooling for the National 5 qualifications, the attainment level is lower for the subject than for chemistry and physics. The Trends in attainment show relative slight increase for all three subjects, rising from 65% (Biology), 74% (Chemistry) and 69% (Physics) in 2014 to 73%, 77% and 74% respectively in 2018.

5.5 National 5 biology, chemistry and physics Attainments by gender

The attainment records for the National 5 examinations by gender is presented in Figures 1.4a, 1.4b and 1.4c for biology, chemistry and physics respectively.

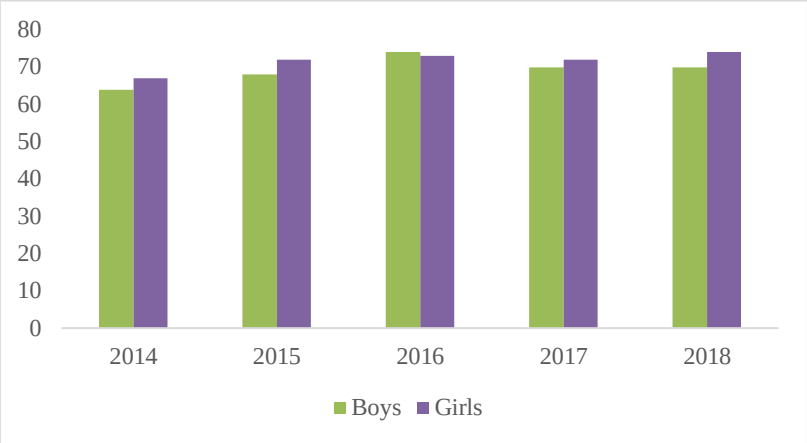

Figure 1.4a: National 5 percentage Biology Attainment by gender

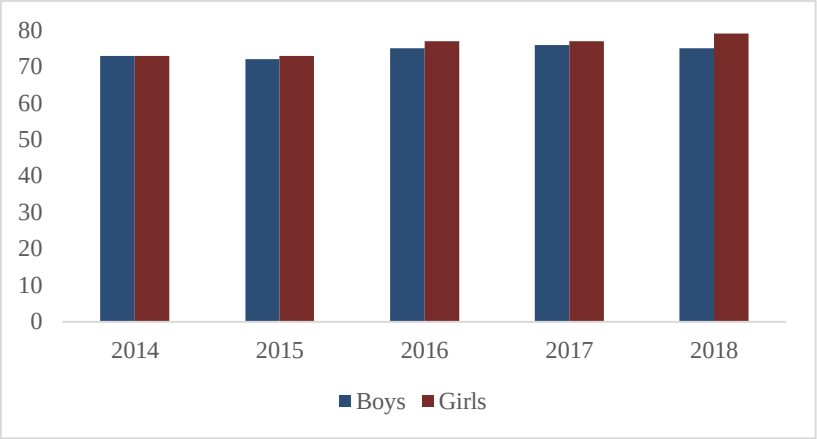

Figure 1.4b: National 5 percentage Chemistry Attainment by gender

Data on science attainment by gender shows that more proportion of girls than boys generally attain the A-C pass grades in all three science subjects. In biology, the percentage of attainment was higher for girls than boys since 2014, except for 2016 when boys recorded a higher pass rate. In chemistry, both boys and girls had 73% passing with A-C grades in 2014, while girls recorded slightly higher pass rates than the boys from 2015 to 2018.

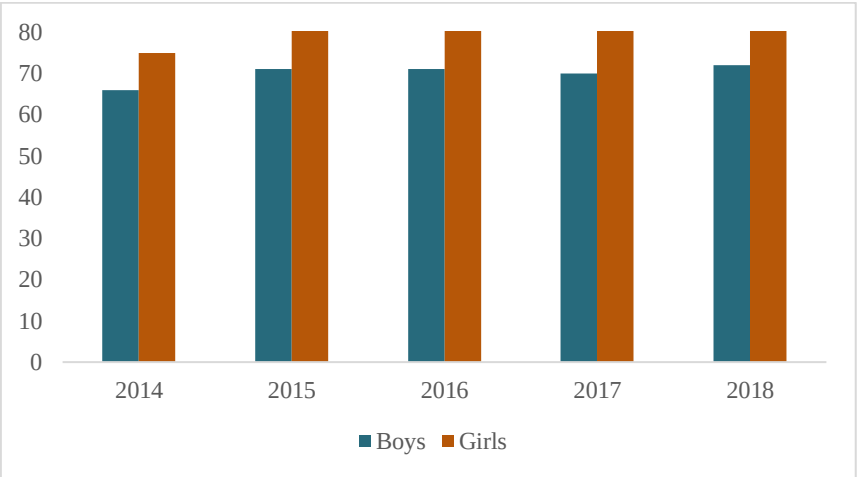

Figure 1.4c: National 5 percentage Physics Attainment by gender

Interestingly, although girls made up only about a third of physics classes for the National 5 examinations, the percentage of A-C grade pass was higher for girls than for boys for all the years.

An independent sample t-test was conducted using SPSS, to compare the mean percentage attainment of boys and girls in biology, physics and chemistry. The results show a significant difference in the mean percentage physics attainment for boys (X=70, SD=2.3) and girls (X=81.2, SD=3.6) with $t(8)=5.79$, $p<.05$. There were no significant differences in the mean percentage attainments for biology and chemistry.

6. Scottish Higher Science Enrolment and Attainment data

To investigate the trend of science enrolment and attainment at the Scottish Higher level, results for Eleven years (2008-2018) have been computed for biology, chemistry and physics. Also, the enrolment and attainment data were analyzed with respect to gender for each subject. The results and charts are presented below.

6.1 Scottish Higher Science Enrolment data

The Scottish Higher enrolment data for biology, chemistry and physics is presented in Table 2.1. In brackets are the percentage enrolments for each subject relative to the total entry for the examination. The Table shows a slight decline in percentage enrolment for biology, chemistry and physics from 2008 with a sudden increase in 2015. A remarkable decline in enrolment can be observed from 2015 to 2016 for all three subjects – dropping from 7.7%, 6.9% and 6.6% in 2015 to 3.8%, 5.1% and 4.6% for biology, chemistry and physics respectively. A trend plot for the three subjects is presented as Fig. 2.2.

Table 2.1: Higher Enrolment Trend for biology, chemistry and physics

Years	Total Entries	Biology Entry (%)	Chemistry Entry (%)	Physics Entry (%)
2008	162576	9132 (5.6)	9505 (5.8)	8765 (5.4)
2009	167792	9107 (5.4)	9582 (5.7)	9002 (5.4)
2010	175614	9308 (5.3)	10179 (5.8)	9018 (5.1)
2011	178925	9771 (5.5)	10239 (5.7)	9447 (5.3)
2012	181699	9554 (5.3)	10364 (5.7)	9171 (5.0)
2013	182730	9971 (5.5)	10004 (5.5)	8793 (4.8)
2014	191859	10197 (5.3)	10717 (5.6)	9098 (4.7)
2015	92,568	7127 (7.7)	6391 (6.9)	6118 (6.6)
2016	197750	7492 (3.8)	10077 (5.1)	9129 (4.6)
2017	194804	7575 (3.9)	10135 (5.2)	8956 (4.6)
2018	191951	7305 (3.8)	9990 (5.2)	8280 (4.3)

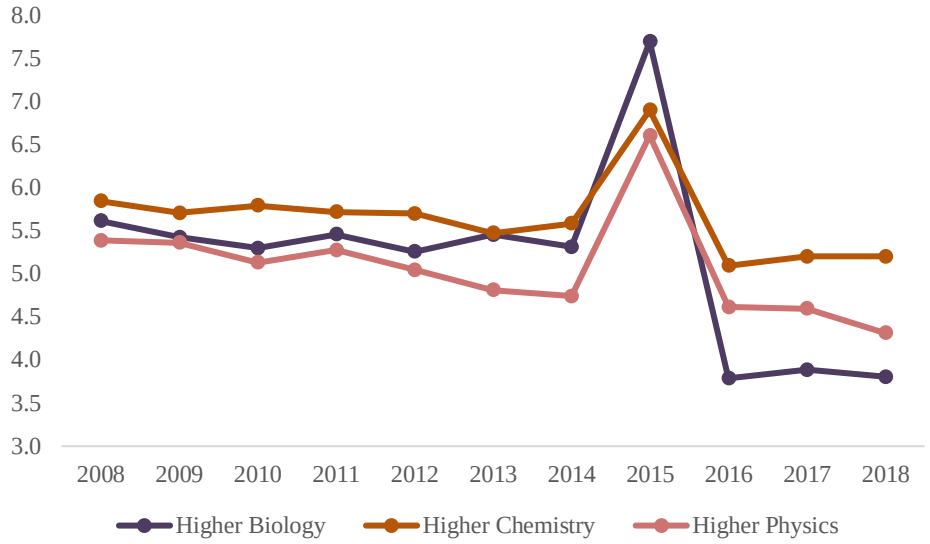

Figure 2.2: Higher biology, chemistry and physics percentage enrolment Trends

Figure 2.2 shows that for the Higher qualification, chemistry is the most popular science subject chosen by pupils after the compulsory years of schooling in Scotland, except in 2015 when more students enrolled for biology than chemistry and physics. Physics has remained the least chosen subjects among the three science subjects as for the National 5 qualifications. In addition, apart from 2015, a general downward trend in enrolment is observed for all three subjects with percentage enrolment falling from 5.6%, 5.8%, and 5.4% for biology, chemistry and physics in 2008 to 3.8%, 5.2% and 4.3% respectively in 2018. This necessitates a further research to investigate the decline in science enrolment.

6.2 Higher biology, chemistry and physics enrolments by gender

The percentage enrolments for boys and girls for all three science subjects chosen at the Higher level is presented as graphs in Figures 2.2a, 2.2b and 2.2c

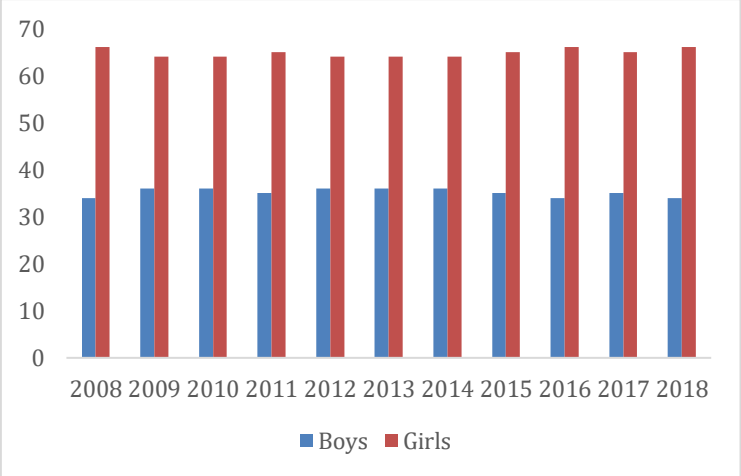

Figure 2.2a: Higher percentage enrolment in biology by gender

Figure 2.2b: Higher percentage enrolment in chemistry by gender

Figure 2.2c: Higher percentage enrolment in physics by gender

Data as presented in Figure 2.2a shows that for the Higher qualification, more girls choose to study biology than boys. For chemistry, Fig. 2.2b shows that equal percentage of boys and girls enroll for chemistry 2009, 2010, 2011 and 2014. Also, while more boys enrolled for the subject in 2008 and 2012, there were more girls in chemistry classrooms for the Higher qualification in Scotland in 2013 and from 2015 to 2018. Figure 2.2c shows that the number of boys in physics classrooms has been consistently more than double that of girls for the Higher qualification in Scottish schools.

6.3 Higher Qualifications Science Attainment in Scotland

The A-C grade percentage attainment in the Higher examinations for biology, chemistry and physics from 2008 to 2018 is presented in Table 2.2.

Table 2.2: Higher Attainment (A-C grades) for biology, chemistry and physics (%)

Years	Biology	Chemistry	Physics
2008	71	78	74
2009	72	77	77
2010	70	77	78
2011	72	78	78
2012	73	80	78

2013	71	78	77
2014	69	76	75
2015	72	75	76
2016	69	77	74
2017	72	76	76
2018	73	77	76

The attainment data shown in Table 2.2 does not reveal any significant improvement or decline in science attainment since 2008 in Scotland (see also Fig. 2.3b)

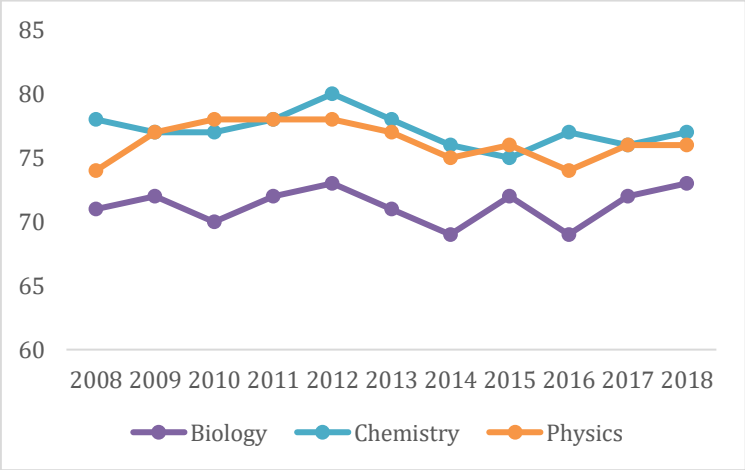

Figure 2.3b: Trends in Higher biology, chemistry and physics A-C (%) attainment

Data shows that chemistry and physics recorded higher percentage of A-C grades than biology with chemistry having higher percentage attainment in seven out of the eleven years under review. The percentage of attainment was higher for chemistry in 2008, 2012-2014, 2016 and 2018. The percentage attainment was the same for physics and chemistry in 2009 (77%), 2011 (78%) and 2017 (76%), while physics got the highest in 2010 and 2015. The trends have not shown any significant improvement in attainment.

6.4 Higher biology, chemistry and physics Attainments by gender

The biology, chemistry and physics attainment data for the Higher examinations by gender is presented in Figures 2.4a, 2.4b and 2.4c respectively.

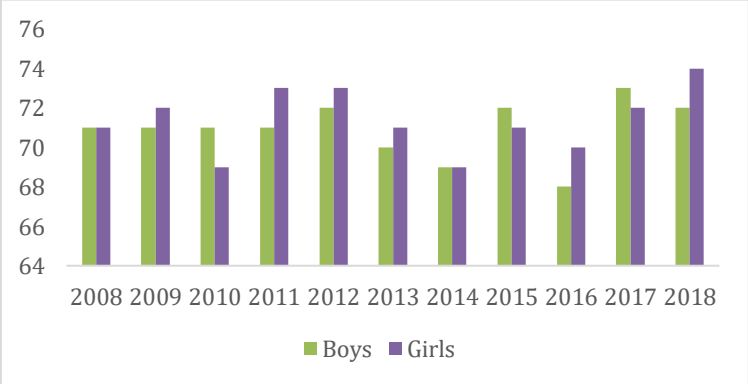

Figure 2.4a: Higher Biology (%) Attainment by gender

Figure 2.4b: Higher Chemistry (%) Attainment by gender

Data on biology attainment for the Higher examinations shows that girls recorded higher percentage of A-C grade passes in five of the eleven years, while boys lead in only three years (Fig. 2.4a). Both boys and girls recorded the same percentage of A-C grade passes in 2008 and 2014. In Chemistry, boys recorded slightly higher percentage (difference of 1% and 2%) from 2008 – 2010, while girls took the lead with 1% difference in 2011. Both boys and girls had the same percentage from 2013 to 2015, before girls took up slight lead in 2016 and 2017. The pattern of attainment by gender for biology and chemistry in Higher clearly deviates from that of National 5.

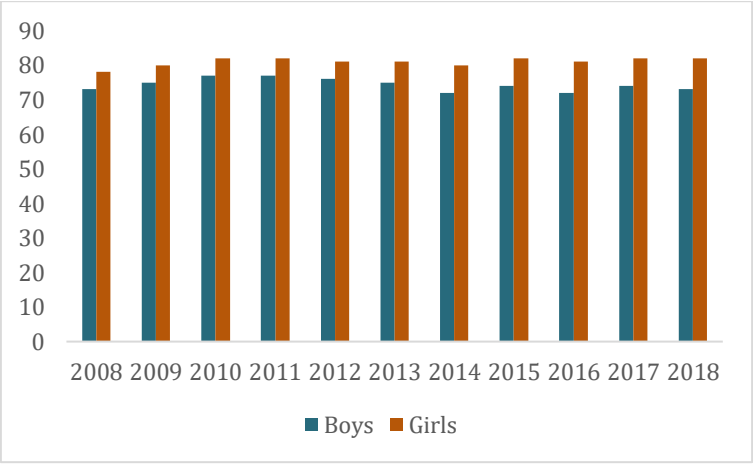

Figure 2.4c: Higher Physics (%) Attainment by gender

For physics, the percentage of girls attaining A-C grade passes in Higher examinations is consistently higher than that of the boys. Girls make only about a quarter of Higher physics classes in Scotland.

An independent sample t-test conducted using SPSS, to compare the mean percentage attainment of boys and girls in Higher biology, physics and chemistry showed a significant difference in the mean percentage physics attainment for boys (X=73.4, SD=1.80) and girls (X=81, SD=1.26) with $t(20)=9.99$, $p<.05$. There were no significant differences in the mean percentage attainments for biology and chemistry.

7. Scottish Advanced Higher Science enrolment and attainment data

Trend of science enrolment and attainment at the Scottish Advanced Higher level from 2008-2018 have been computed for biology, chemistry and physics. Also, the enrolment and attainment data were analyzed with respect to gender for each subject. The results and charts are presented below.

7.1 Advanced Higher Science Enrolments

The Advanced Higher enrolment data for biology, chemistry and physics is presented in Table 3.1. In brackets are the percentage enrolments for each subject relative to the total entry for the examination.

Table 3.1: Advanced Higher Enrolment Trend for biology, chemistry and physics

Years	Total Entries	Biology Entry (%)	Chemistry Entry (%)	Physics Entry (%)
2008	18854	1955 (10.4)	2143 (11.4)	1403 (7.4)
2009	19648	2095 (10.7)	2183 (11.1)	1550 (7.9)
2010	20585	2177 (10.6)	2226 (10.8)	1736 (8.4)
2011	21431	2288 10.7)	2472 (11.5)	1757 (8.2)
2012	21593	2417 (11.2)	2496 (11.6)	1917 (8.9)
2013	22119	2458 (11.1)	2545 (11.5)	1867 (8.4)
2014	22431	2518 (11.2)	2393 (10.7)	1815 (8.1)
2015	23350	2425 (10.4)	2448 (10.5)	1845 (7.9)
2016	23794	2362 (9.9)	2614 (11.0)	1923 (8.1)
2017	24107	2252 (9.3)	2523 (10.5)	1860 (7.7)
2018	24331	2319 (9.5)	2591 (10.6)	1891 (7.8)

The data in Table 3.1 shows that although the total entries have increased since 2008, the same cannot be said for the percentage enrolment for all three subjects. The percentage enrolment for physics increased slightly from 7.4% in 2008 to 8.4% in 2010 and started undulating since 2011 to 2018. The enrolments for biology increased slightly from 2010 with 10.6% to 11.2% in 2012, started undulating up to 2014 before dipping from 2015 to 9.3% in 2017. Figure 3.2 shows a trend plot for all three subjects at Advanced Higher level.

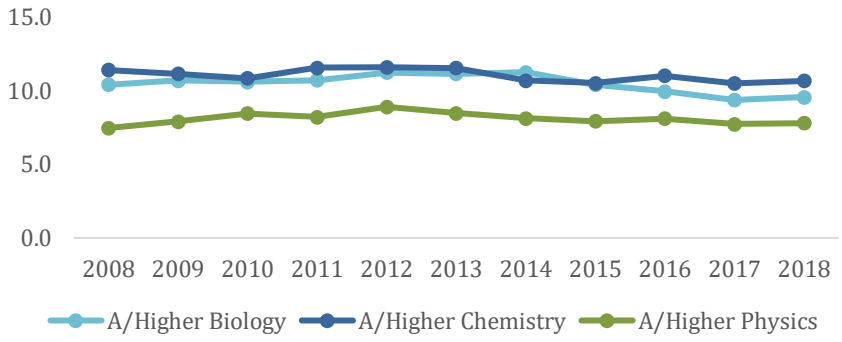

Figure 3.2: Comparing Advanced Higher biology, chemistry and physics percentage enrolments

The data shows that chemistry was the most popular science subject that was taken by students at the Advanced Higher level for all years from 2008 to 2018, except in 2014 when more students enrolled for biology than for chemistry and physics. The pattern was similar to that observed for the Higher examinations, with physics as the least chosen among the three science subjects.

7.2 Advanced Higher biology, chemistry and physics enrolments by gender

A comparison of the percentage enrolments for boys and girls for biology, chemistry and physics at the Advanced Higher level is presented in Figures 3.2a, 3.2b and 3.2c

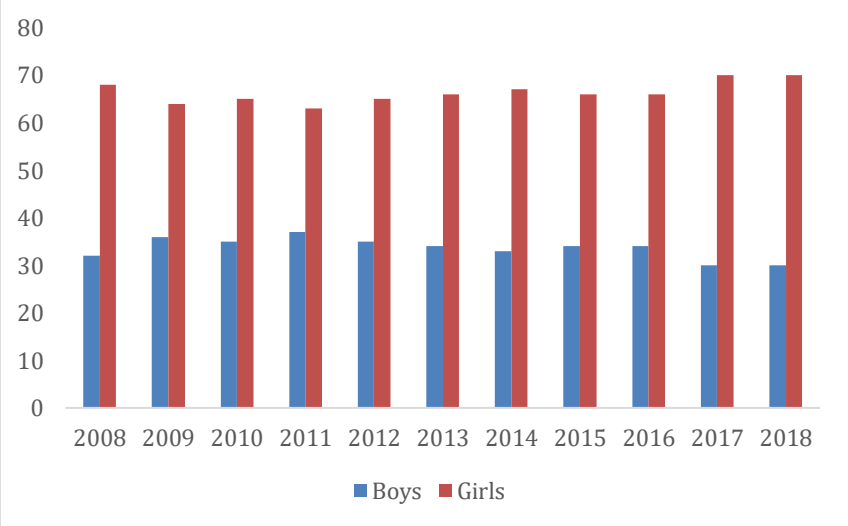

Figure 3.2a: Advanced Higher percentage enrolment in biology by gender

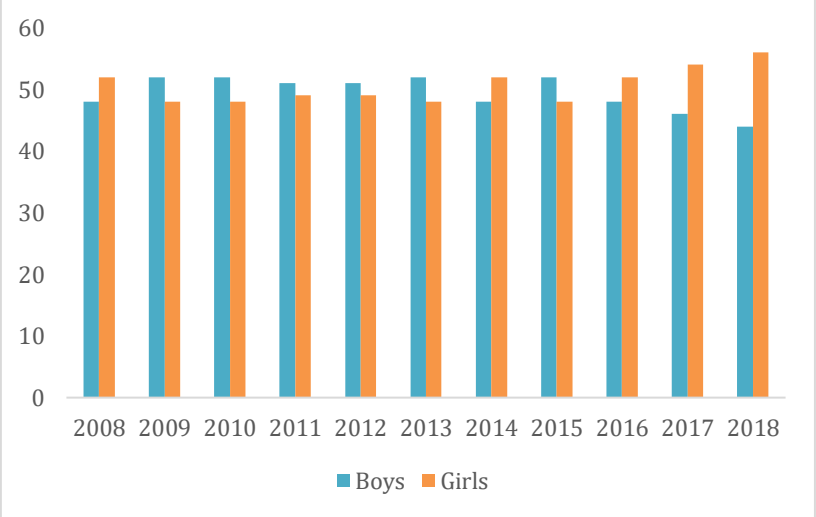

Figure 3.2b: Advanced Higher percentage enrolment in chemistry by gender

Figure 3.2c: Advanced Higher percentage enrolment in physics by gender

Data as presented in Fig. 3.2a shows that at the Advanced Higher level, more girls enroll for biology than boys with nearly a ratio of 2:1. For chemistry, more girls enrolled in 2008, 2014 and 2016 to 2018, while more boys entered for the examination from 2009 to 2015, except in 2014. The situation appears quite different for physics with more boys choosing to study physics at the Advanced Higher level than girls with a ratio of about 4:1.

7.3 Advanced Higher Science Attainment in Scotland

Students' percentage A-C grade attainment in the Advanced Higher examinations for biology, chemistry and physics from 2008 to 2018 is presented in Table 3.2.

Table 3.2: Advanced Higher % Attainment (A-C grades) for biology, chemistry and physics

Years	Biology	Chemistry	Physics
2008	75	77	79
2009	73	79	79
2010	74	78	79
2011	77	80	80
2012	77	80	81
2013	80	81	81
2014	73	77	81
2015	77	80	78
2016	80	83	79
2017	74	84	79
2018	75	82	80

Table 3.2 shows some improvement in attainment for chemistry and physics from 2014 to 2017 and 2015 to 2018 respectively. Students' attainment in biology has been less consistent with a slight increase from 75% in 2008 to 81% in 2013 before dropping to 73% in 2014. It rose to 79% in 2016 and fell again to 74% in 2017 (see also Fig. 3.3).

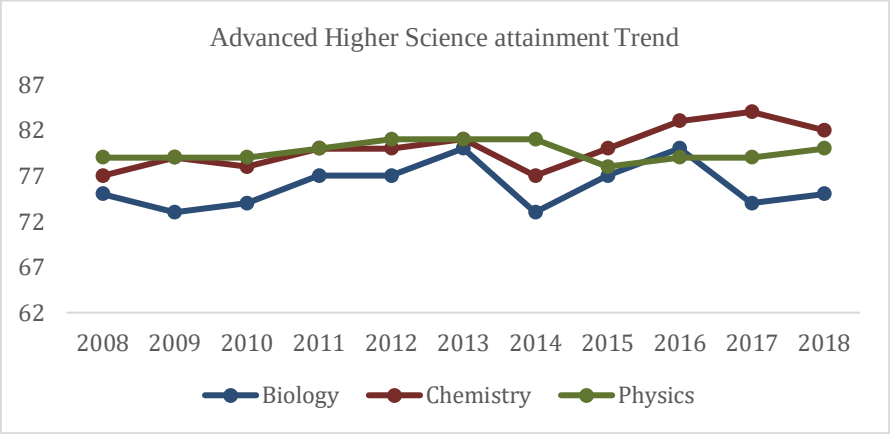

Figure 3.3: Trends in Higher biology, chemistry and physics A-C (%) attainment

Data presented shows that chemistry and physics recorded higher percentage of A-C grades than biology with both having higher percentage attainment in four each, out of the eleven years under review. The percentage of attainment was higher for physics with 79% in 2008 and 2010, and 81% in 2012 and 2014. Since 2015, the percentage attainment in chemistry has been more than physics with an average of about 3%. The trends have not shown any significant improvement in attainment despite government's huge investments in improving school-based science engagement initiatives such as Generation Science, Young Engineers and Science Clubs, British Science Week and GeoBus (Scottish Government, 2018).

7.4 Advanced Higher biology, chemistry and physics Attainments by gender

Science attainment data for the Advanced Higher examinations by gender is presented in Figures 3.4a, 3.4b and 3.4c respectively for biology, chemistry and physics.

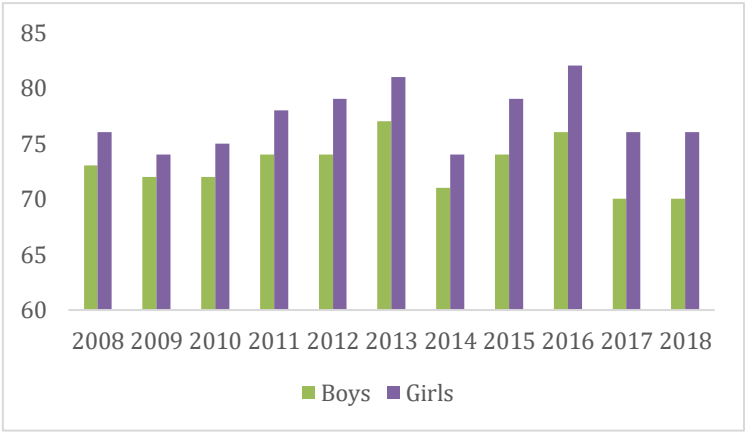

Figure 3.4a: Advanced Higher biology (%) Attainment by gender

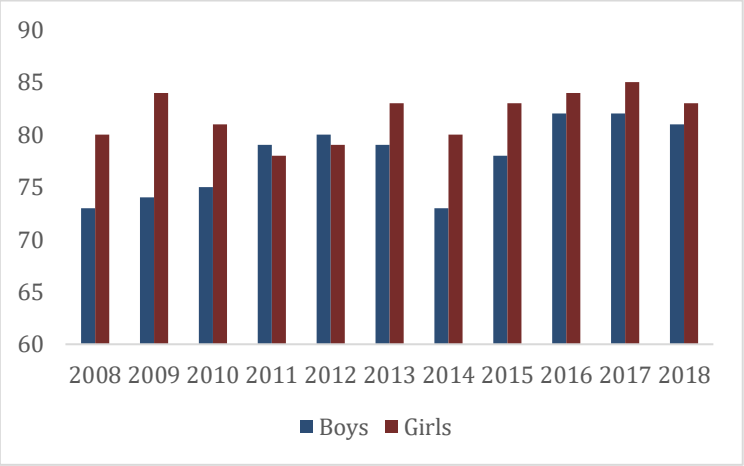

Figure 3.4b: Higher chemistry (%) Attainment by gender

Data on biology attainment for the Advanced Higher shows that girls recorded higher percentage of A-C grade passes than boys (Fig. 2.4a). In Chemistry, except in 2011 and 2012 when boys recorded slightly higher percentage (difference of 1%) than girls, the percentage attainment is higher for girls than boys for the other years averagely by about 5.5%.

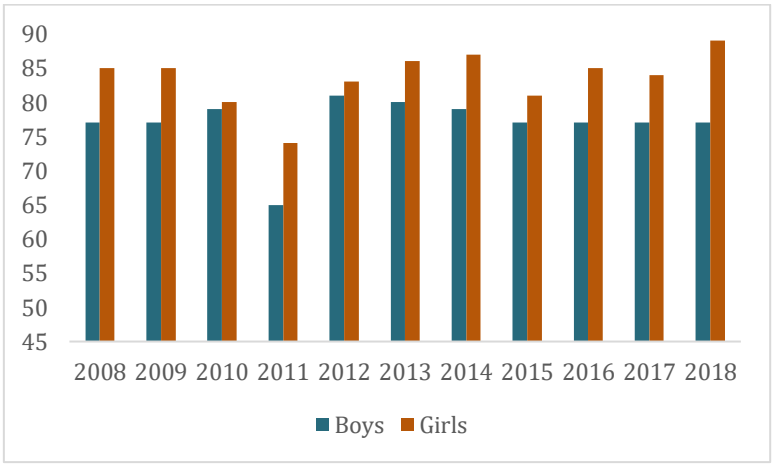

Figure 3.4c: Advanced Higher physics (%) Attainment by gender

For physics, the percentage of girls attaining A-C grade passes in Advanced Higher is consistently higher than that of the boys since 2008. Girls make only about 20% of Advanced Higher physics classes Scotland.

An independent sample t-test conducted using SPSS, to compare the mean percentage attainment of boys and girls in Advanced Higher biology, physics and chemistry showed a significant difference in the mean percentage attainment in all three subjects. For biology: boys (X=73, SD=2.28), girls (X=77.3, SD=2.72) with t(20)=3.99, p=.001; Chemistry: boys (X=77.8, SD=3.49), girls (X=81.8, SD=2.32) with t(20)=3.169, p=.005 and for physics: boys (X=76.9, SD=4.21), girls (X=83.5, SD=4.06) with t(20)=3.77, p=.001.

8. Discussion of findings

Finding from this study shows low enrolment for all three science subjects for the National 5, Higher and Advanced Higher in Scotland. The mean percentage enrolments for the National 5 for biology, chemistry and physics from 2014 to 2018 were 7.4, 5.9 and 5.1 respectively. For Higher, the mean percentages enrolments from 2008 to 2018 were 5.2, 5.7 and 5.1 respectively for biology, chemistry and physics, while for Advanced Higher the percentages were 10.5, 11 and 8.1 for biology, chemistry and physics respectively. Findings also show a decline in percentage enrolments for all three subjects especially for the National 5 and Higher qualifications. physics is the least chosen science subjects after the compulsory years at all levels (National 5, Higher and Advanced Higher) of secondary education in Scotland. Chemistry is the most popular science subject in both S5 and S6 for the Higher and Advanced Higher qualifications, while biology is the most chosen science subject by pupils in S4 for the National 5 examinations. The findings in this study on the low science enrolment in Scotland is consistent with those reported for England, Wales, United States, Canada and Australia (Osborne, *et al.*, 2003; Bennett, Hampden-Thompson and Lubben, 2013; Kennedy, Lyons and Quinn, 2014). In England, percentage GCSE enrolments for biology, chemistry and physics in 2017 were each 2.7%, while A-Level enrolments in 2018 were 7.8 for biology, 6.7 for chemistry and 4.7 for physics (Joint Council for Qualifications, 2018). Also, Kennedy *et al.,* (2014) reported that "*participation in science and mathematics courses by Australian Year 12 students … has been declining in real terms for the greater part of the past two decades and continue to do so in 2012*" (p.44). These findings suggest that possible causes of low and declining enrolment in science subjects when students make choice of subjects to study may be global and necessitates the need for further research to reverse the trend.

On gender and enrolment, results show that more girls than boys enrolled for biology and chemistry for the National 5 examinations, while the number of boys enrolled for physics is more than double the number of girls. For the Higher and Advanced Higher qualifications, more girls entered for biology, more boys for physics while there were about an equal numbers of boys and girls for chemistry. The data also shows that the higher the qualification, the wider the difference becomes in enrolment between boys and girls for physics. The findings of this study for Scotland agrees with those reported in literature that more girls than boys choose to do biology and that boys dominate physics classes when students make choice of subjects after the years of compulsory schooling (See Barnes, McInerney and Marsh, 2005; Bennett, *et al.,* 2013). However, the findings suggest that the assertion that fewer girls choose science and that "*girls consistently show less positive attitudes to it than boys, display lower self-efficacy in it , and may identify science as being masculine*" (Palmer, Burke and Aubusson, 2017, p. 647) needs to be reexamined as this is only true for physics and not biology and chemistry. This is consistent with the views of Britner (2008) that the positive self-concept of girls or otherwise varies within areas of science. Research suggests that after the compulsory years of schooling, male students in coeducational schools are most likely to choose physics than their counterparts in single-sex schools and that for girls, a higher

proportion of them in single-sex schools choose physics than those in mixed-schools (See Bennett, *et al.,* 2013). Similarly in England, Gillibrand, Robinson, Brawn and Osborn, (1999) and in Germany, Kessels and Hannover (2008) reported that creating single-sex classes for physics in coeducational schools improved girls' participation and achievement in physics. Jackson (2002) also reported similar positive effects for girls-only mathematics classes in England. Parker and Rennie (2002) advocated same-sex science classroom with gender-sensitive science teaching strategies to encourage more girls' participation in science. To promote more girl-participation in secondary school physics, it might be necessary to experiment the impact of single-sex physics classes in Scottish secondary schools, as there are only a few single-sex schools in Scotland. Moreover, some studies have reported that many girls find physics abstract and masculine in its content, portrayal and illustrations (see for instance, Hoffmann, 2002). Thus, girls' only classes with more focused illustration of topics in context and relevance might be supportive as girls 'respond very sensitively to a change of context' and express 'a relatively high interest in natural phenomena and phenomena that could be perceived by the senses' (Hoffmann, 2002, p.451).

On attainment, more proportion of girls than boys consistently attained higher grades in physics in National 5, Higher and Advanced Higher qualifications in Scotland. For the Advanced Higher qualification, more proportion of girls than boys who entered for chemistry and physics obtained better grades. In biology and chemistry in both the National 5 and Higher, neither the girls nor boys sustained a clear lead, although on the average, more proportion of girls attained better grades. The pattern of attainment in Scotland is similar to that for GCE A-Level in England, Wales and Northern Ireland from 2014 to 2018 with girls clearly out-performing their male counterparts in physics (See Joint Council for Qualifications, 2015, 2016, 2018). Similar records of girls' out-performing their male counterparts is evident in other countries (see Jackson, 2002; Steinmayr and Spinath, 2008; Regan and DeWitt, 2015). Although the presented study has not investigated the differences between boys' and girls' performance, literature suggests that among others, girls' conformity than boys to school and teachers' expectation (Hoffmann, 2002), differences in study cultures and attitude to school (Houtte, 2004) in favor of the girls explain their relative better performance than the boys, personality and motivation (Steinmayr and Spinath, 2008). This calls for a further research to investigate differential gender attainment in science for Scotland. Generally, there appears not to be any significant improvement in science attainment in Scotland despite government's huge investments in improving school-based science engagement initiatives such as Generation Science, Young Engineers and Science Clubs, British Science Week and GeoBus (Scottish Government, 2018). It might therefore be necessary to investigate the effects of these initiatives and interventions on science engagement, enrolment and attainment.

9. Concluding Remarks

In this paper, I have presented some trend analysis of secondary school science enrolment and attainment after the compulsory school years of schooling in Scotland. I have also presented the current state of enrolment and attainment in biology, chemistry and physics by gender for the National 5, Higher and Advanced Higher qualifications in Scotland. That data presented in this paper has shown a slight decline in science enrolment in Scotland particularly for the National 5 and Higher qualifications. This is despite some interventions by government and other stakeholders like WELLCOME Trust to increase pupils' engagement and uptake of science in primary and secondary schools in Scotland and necessitates a further research to investigate the decline in science enrolment. This study has also shown that girls are underrepresented in physics classrooms in Scotland in spite of the fact that a greater proportion of them make better grades in the subject than the boys. The persistent underrepresentation of girls in physics classrooms calls for the conduct of a further research to investigate the imbalance in gender participation despite all efforts by government and other organizations such as the Institute of Physics (IOP), the Royal Society of Chemistry and the Improving Gender Balance Scotland (IGBS) of the Scottish government. The data also shows that although biology is the most popular science subject among students after the compulsory years of schooling for the National 5 qualifications, the attainment level is lower for the subject than for chemistry and physics. This may be of interest for a further investigation of, for instance, why biology is the most chosen science subject at the Nat 5 level and why is it the least science subject with good pass grades compared to chemistry and physics.

References

Amunga, J. K., Amadalo, M. M., & Musera, G. (2011). Disparities in chemistry and biology achievement in secondary schools: Implications for vision 2030. *International Journal of Humanities and Social Science.* 1(18), 226-236.

Barnes, G., McInerney, D. M. and Marsh, H. W. (2005). Exploring sex differences in science enrolment intentions: An application of the general model of academic choice. *The Australian Educational Researcher,* 32(2), 1-23.

Bennett, J., Lubben, F. & Hampden-Thompson (2013). Schools that make a difference to post-compulsory uptake of physical science subjects: some comparative case studies in England. *International Journal of science Education*, 35(4), 663-689.

Breakwell, G. M. & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science,* 1, 183-197.

Britner, S. L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching,* 45(8), 955–970.

Buccheri, G., Gurber, N. A. and Bruhwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education,* 33(1), 159-178.

Education Scotland (2018). *Sciences.* Retrieved online at https://education.gov.scot on 03/08/2018.

Francis, L. J., & Greer, J. E. (1999). Measuring attitude towards science among secondary school students: the affective domain. *Research in Science & Technological Education,* 17(2), 219-226.

Garg, K. C. and Gupta, B. M. (2003). Decline in science education in India – A case study at +2 and undergraduate level. *Current Science* 84(9), 1198-1201.

Gillibrand, E., Robinson, P., Brawn, R. and Osborn, A. (1999). Girls' participation in physics in single sex classes in mixed schools in relation to confidence and achievement. *International Journal of Science Education.* 21(4), 349-362.

Henriksen, E. K. (2015). Introduction: Participation in Science, Technology, Engineering and Mathematics (STEM): Presenting the challenge and introducing project IRIS. In E. K. Henriksen, J. Dillon and J. Ryder (Eds). *Understanding Student Participation and Choice in Science and Technology Education.* NY: Springer.

Houtte, M. V. (2004). Why boys achieve less at school than girls: the difference between boys' and girls' academic culture. *Educational Studies*, 30(2), 159-173.

Jackson, C. (2002). Can single-sex classes in coeducational schools enhance the learning experiences of girls and/or boys? An exploration of pupils' perceptions. *British Educational Research Journal,* 28(1), 37-48.

Joint Council for Qualifications (2015, 2016, 2018). *Examination Results.* Retrieved online at https://www.jcq.org.uk/examination-results on 23/08/2018.

Kennedy, J. P., Lyons, T. and Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. *Teaching Science*, 60(2), 34-46.

Kessels, U. and Hannover, B. (2008). When being a girl matters less: Accessibility of gender-related self-knowledge in single-sex and coeducational classes and its impact on students' physics-related self-concept of ability. *British Journal of Educational Psychology*, 78(2), 273-289.

Mujtaba, T. & Reiss, M. J. (2013). What Sort of Girl Wants to Study Physics After the Age of 16? Findings from a Large-scale UK Survey. *International Journal of Science Education*, 35(17). 2979-2998.

Mujtaba, T., Sheldrake, R., Reiss, M. J. and Simon, S. (2018). Students' science attitudes, beliefs, and context: associations with science and chemistry aspirations. *International Journal of Science Education,* 40(6), 644-667.

Ormerod, M. B. (1975). Subject preference and choice in co-educational and single-sex secondary schools. *British Journal of Educational Psychology.* 45(3), 257-267.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education,* 25(9), 1049-1079.

Palmer, T., Burke, P. F. and Aubusson, P. (2017). Why students choose and reject science: a study of the factors that students consider when selecting subjects. *International journal of Science Education,* 39(6), 645-662.

Parker, L. H. and Rennie, L. J. (2002). Teachers' implementation of gender-inclusive instructional strategies in single-sex and mixed-sex science classrooms. *International Journal of Science Education,* 24(9), 881-897.

Perera, J. & Velummayilum, P. (2008). Women's career choice and gender roles: a South Asian experience. *The Clinical Teacher*, 5(3), 186 – 190.

Regan, E. and DeWitt, J. (2015). Attitudes, Interest and Factors Influencing STEM Enrolment Behaviour: An Overview of Relevant Literature. In E. K. Henriksen, J. Dillon and J. Ryder (Eds). *Understanding Student Participation and Choice in Science and Technology Education.* NY: Springer.

Semela, T. (2010). Who is joining physics and why? Factors influencing the choice of physics among Ethiopian university students. *International Journal of Environmental & Science Education*. 5(3), 319 – 340.

Stables, A. (1990). Differences between pupils from mixed and single-sex schools in their enjoyment of school subjects and in their attitude to science and to school. *Educational Review,* 42 (3), 221-230.

Steinmayr, R. and Spinath, B. (2008). Sex differences in school achievement: what are the roles of personality and achievement motivation? *European Journal of Personality*, 22, 185-209.

Tripney, J., Newman, M., Bangpan, M., Niza, C., MacKintosh, M. and Sinclair, J. (2010). Subject choice in STEM: Factors influencing young people (aged 14-19) in education – A systematic review of the UK literature. Report commissioned by the Wellcome Trust. London: University of London Institute of Education.