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Mathematics as the gateway: Primary education influences on upper secondary physics and chemistry enrolments

Key insights from recent research:

- Recent research from the ***Growing Up in Ireland Study*** considers the **impact of primary and lower secondary experiences on girls' enrolment in physics and chemistry in upper secondary school.**
- The authors identified key benefits for girls attending single-sex schools, who had a higher uptake of physics and chemistry study in upper secondary.
- This was **further supported by positive attitudes, career aspirations and performance in mathematics,** with a **key age point for these benefits to occur being nine years of age.**

Do girls' early educational experiences impact science enrolments in upper secondary education, especially for subjects like physics and chemistry? And will understanding this help support girls as they navigate STEM subject choices? These are the questions asked by researchers from Ireland who have used data from the *Growing Up in Ireland Study* to consider how single-sex education and early education experiences can impact girls' secondary subject choices. The authors have found some consistent correlations that reinforce the benefits of an all-girls learning environment and engagement with mathematics, with suggestions for interventions that can be considered for increased impact in this area.

Research has already extensively considered why girls may choose to study STEM. This article looks at a "life-course approach" to determine how much impact early student experiences have on secondary subject choices, when these experiences matter, and how they specifically impact students. Using data from over 6,000 students aged nine to 17, the authors looked at gender and social mix in primary schools, science-career aspirations, and student attitudes and aptitude in mathematics in primary school for impact on later science uptake. In secondary school cohorts, they also considered if the gender and social mix had any further impact, as well as student experiences and attitudes to mathematics and science in lower secondary school.

The authors raised a number of points about school characteristics, girls and STEM that will come as no surprise to educators. It has been acknowledged that girls are less likely to study subjects such as physics than boys, which contributes to the STEM gender gap. The research

identified that regardless of gender composition, socio-economically disadvantaged schools were less likely to offer both physics and chemistry to students, with larger and greater-resourced schools more likely to offer these subjects.

Girls who attended single-sex primary schools are significantly more likely to study physics in secondary school than their counterparts who attended co-educational schools. This created a significant benefit in the study cohort and reinforces the benefits offered by girls' schools. The option to study a more diverse range of science subjects in lower secondary school also acted as a gateway to continuing or undertaking physics in upper secondary school. Higher levels of performance in mathematics and science in girls' schools during earlier year levels also correlated with a higher uptake of chemistry in upper secondary school.

These benefits were enhanced by attitudes towards mathematics and science both as subjects, and as careers. The research found that mathematics acts as an important "gateway to both chemistry and physics, especially for girls". Higher performance levels in mathematics during primary school correlated with a higher uptake of physics and chemistry study in upper secondary. In fact, more positive attitudes towards mathematics at age nine, regardless of test scores, correlated with higher physics enrolments in secondary school.

The same correlation was observed for students who expressed aspirations for a science-related career at age nine. This was particularly observed in girls who reported finding science "interesting". Career aspirations to work in a science-related field were also observed to have an impact when expressed at age 13, but less so than aspirations observed at age nine. Parental involvement in a science-related employment field also had a positive impact. Again, the benefit of this occurred as early as nine years of age.

This raises some key points for girls' schools. Providing a subject alone is not enough. There are long-term consequences of experiences in primary school, especially the social and gender composition of the school. Single-sex schools significantly reduce the gender stereotyping that can impact girls' engagement with physics in upper secondary school. The correlation between mathematics and the later uptake of chemistry and physics was a particular benefit identified by the authors. They suggest that encouraging early and positive engagement with mathematics is essential, because negative attitudes correlate with significantly reduced enrolments in both physics and chemistry. Career aspirations and attitudes toward mathematics and science have crucial impacts for girls – especially those occurring at nine years of age. While adolescence was also a critical point (with age 13 identified by the authors as a key stage), the earlier age range was deemed much more significant.

Despite these benefits, students who had previously attended schools in designated disadvantaged areas, especially those in rural areas, still saw a lower rate of physics enrolments. The authors suggest that educators must be aware of the potential long-term impact of these experiences. Students who have attended socio-economically disadvantaged schools are less likely to study physics or chemistry, even when taking into account other positive influencing factors. As such, they suggest that these girls may require additional support to explore the options available to them during upper secondary school.

Many of the points raised are already addressed in girls' schools, not least the offer of diverse subject choices, encouragement of early and positive engagement with these subjects, and multiple pathways to explore these options. The authors do recognise the benefit of interventions already being used to support girls in this area. However, they have put forward some additional strategies on the basis that "transforming mainstream educational practice rather than relying on stand-alone interventions" will be increasingly beneficial.

These interventions include providing a fully engaging and accessible early mathematics education as a foundation. They further encourage engagement with science career aspirations and opportunities in primary school, rather than waiting for lower and upper secondary education to introduce students towards information and options in this area. When supporting all students, especially those from lower resourced schools or socio-demographic contexts, it is important to avoid constructions of science and mathematics as "difficult and only suited to more advantaged and higher achieving students". In this context, the authors suggest this includes girls who may not have been exposed to family members with higher education opportunities or careers in science-related fields.

The authors conclude by proposing that there is the opportunity of significant positive outcomes when combining these considerations with a focussed approach to attitudes, aspirations and subject performance in mathematics in primary and lower secondary school. By doing so, they emphasise the possibility of greater opportunities for increased engagement with physics and chemistry in upper secondary school. This can create potential for further progress to be made towards closing the STEM gender gap and supporting girls to fully explore the diverse range of options available in their study choices.

References

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