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Executive summary

- The insufficient number of young people wanting to take up science and maths beyond compulsory education has been worrying in the light of predicted demands for STEM skills by employers.
- The introduction of the STEM informal education sector was a direct outcome of the high priority STEM agenda. STEM enrichment and enhancement activities were introduced at the local and national level to help young people appreciate science and maths.
- Activities such as hands-on practical sessions, STEM ambassador visits and visits to state-of-the-art laboratories in higher education institutions (HEIs) and centres have been run for more than a decade now, using significant resources. How successful have these activities been?
- The purpose of this report is to share research evidence from a national evaluation of the impact of STEM enrichment and enhancement activities on improving attainment (GCSE maths and science), increasing and widening STEM participation (AS and A level) in England.
- A direct noticeable effect of these activities on improving school or pupil educational outcomes was not found. Young people participating in these activities neither attained higher in GCSE science or maths nor were they any more likely to consider studying STEM subjects after compulsory education.
- However, rather than suggesting that these strategies are ineffective these findings may help reflections on what works and whether any of this work better than others.

Essential STEM skills and their short supply in the UK

1. Science, technology, engineering and mathematics (STEM) skills are globally valued. In the United Kingdom, serious concerns have long been raised over the apparently insufficient number of young people studying science and maths beyond compulsory education. A range of STEM schemes have been introduced and sustained for over a decade now to raise improve attitudes of students in school towards pursuing STEM subjects and careers. These schemes call for huge investments of time, money, and resources. Over the same period, government reports have pointed out the pressing need for large scale robust evaluations to understand what works in public policy including education. This is important for accountability and to achieve better results by building on the best schemes for similar or reduced investments.

2. Increasing and widening participation in STEM are clearly priorities for the UK education policy as suggested by the Department for Education (DfE) and the UK Parliament. However, in the absence of proper evaluations the impact of spending on STEM schemes on raising attainment or improving participation remains unclear.

Research questions

3. Addressing this gap, using official datasets in the form of the national pupil database (NPD), the impact of participating in STEM enrichment and enhancement activities on educational outcomes of all pupils, disadvantaged pupils and schools with a large share of such pupils was evaluated.

4. The measures of educational outcome considered were – first, attainment in GCSE science and maths for participating schools and pupils; second, continued post-16 STEM participation; were participating pupils more likely to make a STEM subject choice? The study aimed to answer three main research questions:
a. Does continued participation in enrichment and enhancement activities raise school attainment levels?
b. Can STEM activities effectively reduce attainment gaps between underprivileged pupils and their peers?
c. What is the impact of STEM initiatives in widening STEM participation of students from disadvantaged backgrounds?

5. For this study, disadvantaged pupils were identified in the school and pupil level secondary data from NPD based on a) their eligibility for free school meals (FSM) as this is representative of a lower socio-economic status, b) black ethnic minority pupils as they have been shown to be the lowest attaining group who shy away from STEM courses, c) language group, speaking English as an additional language (EAL) as they are also considered under the WP measure in educational research. The regression models also considered gender, prior attainment and statement of special educational needs (SEN).

Key findings

6. Continued participation in STEM enrichment activities did not affect the educational outcomes – school attainment, pupil attainment and continued post-16 STEM participation.

7. Analysis of attainment data for schools in GCSE math and science, showed schools enrolling their students from the beginning of key stage 3 to the end of key stage 4 did not do any better. There was no significant impact of participating in these activities on school attainment.

8. Analysis of pupil level data attainment data showed those participating in these activities did not achieve any higher than others in GCSE science and maths. Intervention pupils did not necessarily consider studying STEM subjects when a choice had to be made.

Impact on school GCSE maths and science results

9. GCSE science and maths results for all schools had improved irrespective of STEM intervention from 2007 to 2012.

10. The achievement gap between intervention and comparator narrowed down significantly after longitudinal intervention. This was because comparator schools had higher attainment than intervention schools after intervention.

11. Intervention schools had a similar or slightly lower share of lower SES pupils (a school level deprivation measure) as comparator schools. A strong negative correlation of similar order was seen in intervention schools as well as the comparator group between FSM and school results. This suggests correlation of school attainment in maths with percentage share of FSM pupils was not affected by STEM intervention. If STEM interventions could negate the effect of school level deprivation factors such as SES it would be expected that the values for correlation coefficient would be lower for intervention groups as opposed to the comparator.

12. A slightly different trend was however noticed for science attainment. Values for correlation coefficients decreased over the years more for comparator than intervention group. This means the effect of poverty on school science attainment had been slightly ruled out for the comparator.
Impact on pupil GCSE maths and science attainment

13. Findings from the analysis of pupil level data supported those from school level data. 76,462 students registered for STEM intervention from the beginning of KS3 (year 7 for the cohort) were tracked to assess the impact of STEM initiatives on pupil maths and science GCSE attainment. The results were matched to a comparator group of 555,295 students. Achievement gap was very small after longitudinal intervention (0.01). The percentage of FSM pupils were same in intervention and comparator group (13%) and exactly similar were the correlation coefficients (-0.2). Thus, pupil participation in STEM activities did not weaken the link between FSM and maths attainment.

14. From amongst the various disadvantage measures considered, SEN pupils were the lowest attaining group, followed closely by FSM eligible pupils. Compared to SEN and FSM pupils, ethnic minorities and EAL pupils did relatively better in GCSE science and maths.

15. A two-way estimation of attainment gap was now carried out for the various disadvantaged groups with varying time periods of exposure to intervention. First, achievement gap between intervention groups and comparator was always nearly zero for the same social group. For example, this meant maths attainment for FSM pupils was the same irrespective of there being in intervention or comparator group.

16. Students from privileged backgrounds continued to attain higher than disadvantaged pupils who were exposed to similar duration of intervention (for example FSM and non-FSM pupils).

17. Students participating in STEM interventions only during KS4 were however the lowest attaining sub-group. R values for intervention group and comparator were exactly same (-0.2). Thus, just as school level data STEM interventions could not rule out the effect of FSM or ethnicity on pupil maths or science attainment.

18. Multiple linear and logistic regression models were created using different maths and science attainment variables (outcome). The findings were similar for science and maths. Regression models confirmed STEM interventions were not a deciding factor for science/maths GCSE attainment. Other independent variables like prior attainment, SES, gender, ethnicity, SEN, language groups can predict science attainment. Inclusion or exclusion of STEM intervention did not make any difference to the models and the R or adjusted R square values remained unchanged. This supports previous findings that STEM interventions have not had a major impact on GCSE maths and science attainment.

Impact on increasing and widening post-compulsory STEM participation

19. A direct noticeable positive effect of engaging in these activities on pupil STEM subject choices was not found. The findings were similar for all pupils irrespective of their background such as socio-economic status or ethnicity. Pupils who were registered by their schools for STEM enrichment and enhancement activities every year did not have any greater likelihood of continuing to study STEM subjects than their peers after compulsory education.
20. A-levels was the most popular qualification route for the cohort. More pupils from intervention groups achieved 5+A*-C in GCSEs and were eligible to take-up A-levels than the comparator. However, results show STEM participation gap was very small between intervention group and comparator for both AS- and A-levels, indicating, STEM interventions did not increase the chances of student’s making STEM subject choices.

Do different time periods of pupil enrolment in these activities affect STEM participation rates?

21. Post-16 participation gap between all intervention groups of varying duration for lower SES pupils and respective comparator was negligible.

22. Young people who had a staggered intervention were the biggest group taking up STEM subjects for A-levels. Most students for this group were not exposed to the intervention regularly so their continuation with STEM subjects cannot be directly attributed to the intervention.

23. The longitudinal intervention group where students were continuously participating in STEM activities from the beginning of KS3 to the end of KS4 each year did not have many students studying STEM subjects’ post-16.

24. Students taking part in interventions only during KS4 had the lowest STEM participation rates. On certain occasions the comparator group schools and pupils performed better than this intervention sub-group.

25. Those who participated in interventions only during KS3 (but never in KS4) were found to be slightly more likely to opt for STEM subjects than the previous group who had interventions only during KS4. This is supported by some research which shows educational interventions early in the life of students are often more effective.

Do disadvantaged students benefit from these interventions?

26. Students from a lower socio-economic status who had regularly participated in these activities did not attain any higher in GCSE science and maths. FSM eligible students who had a staggered intervention because they were not continuously participating were more likely to continue in STEM. However, this sub-group comprised of a large share of pupils who had not regularly been in an intervention school or had moved into the UK from elsewhere. Thus, it is likely that they might have had other exposure/experiences which motivated them to take up STEM subjects at AS/A levels. Equally likely they were perhaps already motivated to study these subjects in the first place and did not need an external influence.

27. Participation gap for black pupils in intervention group and comparator was nearly zero. Also, the chances of their studying STEM subjects were similar in any intervention group or comparator. The percentage participation rates for black pupils was very low between 0-2 percent. Some STEM subjects were not taken by any black ethnic group pupil.

Discussion and conclusions

28. There are indications that school and student performances are gradually improving over the years. Several factors singly or in combination affect subject choices, attitudes and aspirations in secondary school. However, there clearly isn’t a direct evidence to suggest these interventions increase the chances of young people wanting to take up STEM courses.
29. The educational trajectories and life in general is harder for disadvantaged students yet there are students who despite qualifying for several measures of disadvantage embody resiliency. Equally important are the measures adopted by high attaining schools with a high percentage of disadvantaged pupils.

30. Continued participation in STEM enrichment and enhancement activities did not raise school attainment levels. These activities were not effective in reducing the attainment gap between underprivileged pupils and their peers. There was no noticeable positive effect of participation in STEM interventions on educational outcomes of disadvantaged pupils or all participating schools and pupils in general.

Recommendations

31. The STEM enrichment and enhancement activities are being run to support the national STEM agenda. Their administration requires investment of time and resources. There is a need to evaluate what works or works well to be able to direct resources on effective programmes. This will ensure better results are obtained with a similar or reduced investment.

32. If these schemes are not working perhaps the money could even be saved and used elsewhere. For example, reducing tuition fees for STEM courses or reduced tuition for the third year could be an important consideration in the light of growing STEM demand.

33. The duration and point of delivery of intervention was considered in the study. However, interventions only in KS4 were found to be least effective. On certain occasions the comparator group schools and students performed better than this sub-group. Whether these interventions in KS4 produce any damaging effects is something we do not yet know. Research shows educational interventions earlier in the life of students are often more effective.

34. The basic presumption that all pupils could be enrolled in the same intervention is again something to reconsider. There is no causal evidence to explain why disadvantaged pupils are less likely to attain higher and continue participating in STEM.

35. The limited availability of data such as details of participating schools or names is very difficult to obtain for research. It is important to encourage research in this area and hence make such data easily available.

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