2020 cohort

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How does aligning mathematical approaches between the maths and science departments impact year 10 pupil attainment and confidence when answering maths questions in science lessons?

Since 2015, government guidance dictates that 'no less than' 20% of the GCSE qualifications in both Single Science (Biology, Chemistry, Physics) and Combined Science must be mathematical skills (Ofqual, 2015a, 2015b). Therefore, a pupil's ability to successfully complete math skills in the context of science is a sizable contributor to attainment in science. Several studies report teacher observations that students struggle with maths in science lessons (Brodsky, 2008; Dodd & Bone, 1995), for instance because they have trouble applying the 'knowledge they have acquired in GCSE Mathematics to other subjects' (Porkess, 2013). The difficulty students face in transferring knowledge learnt in one subject to another is reported outside of just maths and science (Willingham, 2009). However, the literature lacks quantitative analysis of the success of pupils in maths in scientific contexts.

Despite the two subjects of maths and science being 'by no means mutually exclusive', teachers in various contexts have reported a lack of communication and collaboration between the two departments (Brodsky, 2008; Bryne & Brodie, 2012; Dodd & Bone, 1995; Wong, 2018). This may then create 'problems of consistency in terminology and approaches between the two subjects' (The Association for Science Education, 2016), which may build 'potential barriers to understanding between maths and science for pupils' (Bryne & Brodie, 2012). Again however, no quantitative data exists to support these speculations. Prior to this project, the maths and science departments in the study school had no existing formal dialogue.

The hypothesis investigated in this project is whether alignment of mathematical approaches between the maths and science departments in the study school would improve pupil attainment and confidence when answering maths questions in science lessons. The research project took place over a period of 9 school weeks whilst I taught two year 10 separate science classes Biology Topic 8 from Edexcel GCSE Biology (Pearson Edexcel, 2018). The main research question was divided as follows:

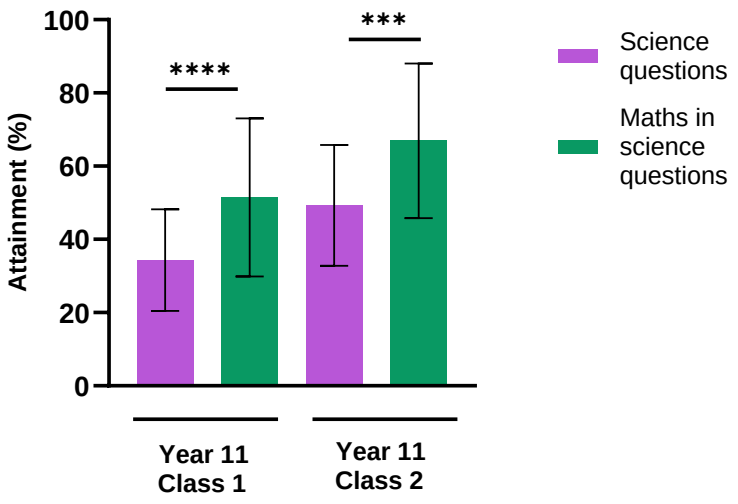
- What is the current attainment of pupils for maths questions in science, compared to pure science questions, in the study school?
- What mathematical approaches (terminology and methodology) are used by the maths department in the study school to teach maths skills required in Biology Topic 8?
- How aligned are the maths and science curricula in the study school for the teaching of maths concepts that are present in Biology Topic 8?
- Can attainment be improved through aligning mathematical approaches between the science and maths departments?
- Can pupil confidence in answering maths questions in science be improved through aligning mathematical approaches between the science and maths departments?

The two parallel classes were used as a control and a test group wherein whilst I taught the purely scientific content of the topic identically to the two classes, I taught the maths skills involved

differently. The control group received teaching of the maths skills as I would have taught it in the absence of this research project. The test group on the other hand received maths teaching that I planned after collaborating with the maths department. This collaboration consisted of weekly meetings between myself and a member of the maths department where we discussed terminology, methodology and curriculum sequencing for mathematical concepts included in Biology Topic 8. To assess the impact of the differential maths teaching, the two classes completed paired pre- and post-tests that I designed to assess attainment (content test) and confidence (questionnaire), and so this project can be defined as having a 'pre-test-post-test control group design' (Cohen et al., 2017). The content tests contained past-paper GCSE maths in science questions and the confidence questionnaire was based on the 5-point Likert-scale method. Non-parametric statistical analysis was performed to compare the pre- and post- tests as well as to compare the control and test group.

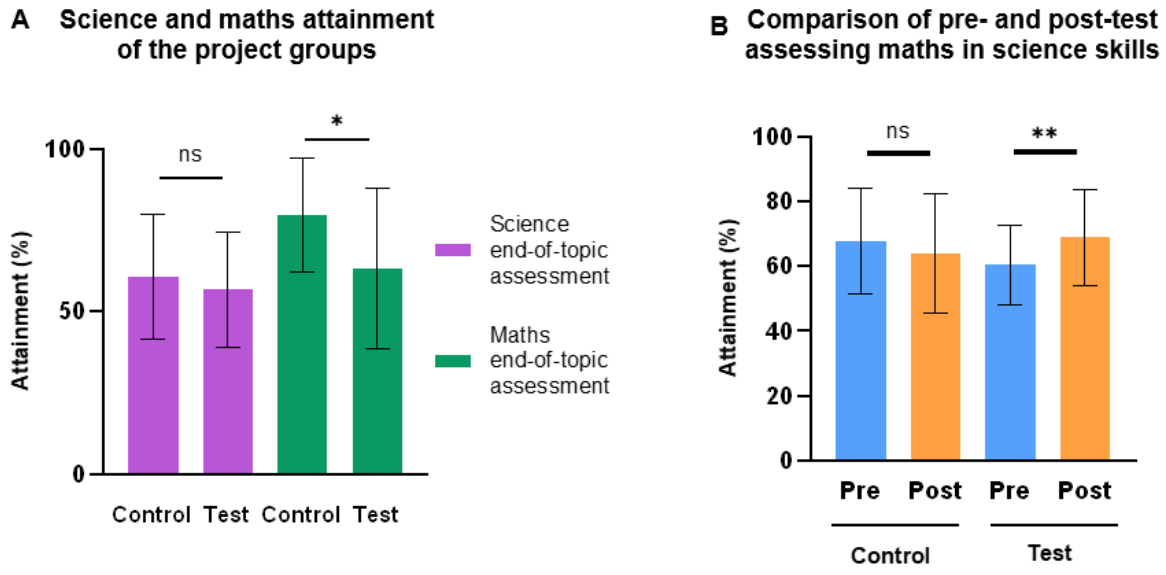
The pre-public exam papers of two year 11 classes were analysed to assess attainment in pure science questions as opposed to questions that required maths skills (Figure 1). The two sampled classes achieved significantly higher in maths in science questions compared to pure science questions with the pupils achieving on average 17.0% and 21.7% more for Class 1 and Class 2 respectively. This data is in possible contradiction to the literature discussing that pupils struggle with maths in science, as it indicates that this sample of pupils actually perform better in science questions that include maths.

Figure 1. Attainment is percentage of marks achieved on pre-public exams, in marks defined as either a science question or a maths in science question. Wilcoxon matched-pairs signed rank test; error bars indicate mean ± standard deviation; ***P < 0.001; ****P < 0.0001.



Analysing attainment of the participating pupils demonstrated that the test group on average generally achieve lower in both maths and science compared to the control group (Figure 2A). Figure 2B shows that in accordance with the general attainment data, the test group achieved slightly lower (3.7%) on the pre-test than the control group. The test group then achieved a statistically significant higher attainment on the post-content test, scoring on average 8.6% higher than the control group. This data could excitingly suggest that aligning mathematical approaches between the maths and science departments can indeed have a positive impact on pupil attainment when answering maths questions in science lessons. No positive or negative impact on confidence was found from analysing the pre- and post-questionnaires in either group (data not shown).

Figure 2. Attainment is percentage of marks achieved on end-of-topic assessments (A) or on the project pre- and post-test (B). Mann-Whitney test (A) and Wilcoxon matched-pairs signed rank test (B); error bars indicate mean ± standard deviation; ns, not significant; *$P < 0.05$; **$P < 0.01$.



Whilst I regard the quantitative and statistical nature of this research to be convincing, several limitations to the project must be observed. To further investigate how robust this claim is, similar research must be conducted with larger sample sizes, and with randomised groups. Furthermore, these results exist only in the context of biology and similar research should be repeated to see if similar results would be found in the context of chemistry and physics. Similarly, these results are also constrained to the context of the study school and year 10 separate science pupils and would need to be repeated in different contexts to see if the conclusions may have a wider significance.

Brodsky, L. (2008). The use of mathematics in ks3/ks4 science classes. *Proceedings of the British Society for Research into Learning Mathematics*, *28*(3).

Bryne, E., & Brodie, M. (2012). *Cross-curricular teaching and learning in the secondary school: science*. Taylor & Francis Group.

Cohen, L., Manion, L., & Morrison, K. (2017). *Research Methods in Education* (8th ed.). Routledge.

Dodd, H., & Bone, T. (1995). To what extent does the national curriculum for mathematics serve the needs of science? *Teaching Mathematics and Its Applications*, *14*(3).

Ofqual. (2015a). *GCSE Subject Level Conditions and Requirements for Combined Science*. Crown. https://www.gov.uk/government/publications/gcse-9-to-1-subject-level-conditions-and-requirements-for-combined-science

Ofqual. (2015b). *GCSE Subject Level Conditions and Requirements for Single Science (Biology, Chemistry, Physics)*. Crown. https://www.gov.uk/government/publications/gcse-9-to-1-subject-level-conditions-and-requirements-for-single-science

Pearson Edexcel. (2018). *GCSE (9-1) Biology Specification Pearson Edexcel Level 1/Level 2 GCSE (9-1) in Biology (1BI0)*.

Porkess, R. (2013). *A world full of data : statistics opportunities across A level subjects*.

The Association for Science Education. (2016). *The Language of Mathematics in Science: A Guide for Teachers of 11-16 Science*. www.ase.org.uk.

Willingham, D. T. (2009). *Why don't students like school?* Jossey-Base.

Wong, V. J. (2018). *The relationship between school science and mathematics education*. https://kclpure.kcl.ac.uk/portal/