Ensuring children have the right knowledge and skills at the right time

Kelly Dockerty examines the implications of the curricular disconnect in the sequencing of maths and science knowledge and skills

Teacher training and in-service practice takes account of what teachers are required to teach according to the statutory Primary National Curriculum (DfE, 2013). When teachers plan to teach curriculum subjects e.g., science and mathematics, they sequence the knowledge and skills according to the prior knowledge children have gained, adapting pedagogical resources to take account of individual children's needs. Knowledge is complex; Ofsted as part of their recent subject reports highlighted different knowledge bases for mathematics (declarative, procedural and conditional knowledge) and for science (substantive and disciplinary knowledge) and therein lies a big challenge for both the training and practice of teachers. Sequencing learning and ensuring that children have the right knowledge and skills at the right time to apply what they have learnt, is at tension with the range of knowledge bases that are not shared between science and mathematics. To illustrate the differences, Box 1 below shows the descriptors Ofsted apply to the knowledge bases in their reports.

Box 1 Knowledge base descriptors from Ofsted (2023a, b)

Knowledge in Mathematics

- Declarative knowledge: facts, concepts, formulae
- Procedural knowledge: methods, procedures, algorithms
- Conditional knowledge: strategies formed from the combinations of facts and methods to reason and problem-solve

Knowledge in Science

- Substantive knowledge: refers to the established knowledge produced by science, for example, the parts of a flower or the names of planets in our solar system. This is referred to as 'scientific knowledge' and 'conceptual understanding' in the national curriculum.
- Disciplinary knowledge: refers to what pupils learn about how to establish and refine scientific knowledge, for example by carrying out practical procedures. By identifying and sequencing this knowledge, it is possible to plan in the curriculum for how pupils will get better at working scientifically throughout their time at school.

The Primary STEM Education Consultancy publication *'Links and Discrepancies between Maths and Science' (2023)* highlights that the science curriculum should be planned to take account of what pupils have or have not learnt in mathematics. However, occasionally pupils are required to demonstrate mathematical skills in science (e.g. drawing a graph) before the skills have been taught in mathematics. It has been suggested that teachers are taking it upon themselves to recognise these natural links and discrepancies between mathematics and science skills when they sequence the learning, to ensure children can experience success in developing their knowledge.

Moreover, as teachers prepare pupils to transition between key stages (e.g. Year 6: Primary to Year 7: Secondary) there is a real danger that the discrepancies in skills between science and mathematics could lead to a deficit in knowledge and lack of confidence amongst pupils. Specific areas of concern related to the transition point between year 6 (ages 10–11, primary) and year 7 (ages 11–12, secondary) are shown in Box 2.

Box 2 Two areas of concern at the transition point

"In science, pupils will sometimes need to gather data that is most appropriately presented as a scatter graph. Constructing scatter graphs is not covered in maths until Key Stage 3 and therefore pupils should not be asked to construct a scatter graph from their data. This kind of data can be gathered using a spreadsheet and the graphing tool should be used to generate the scatter graph.

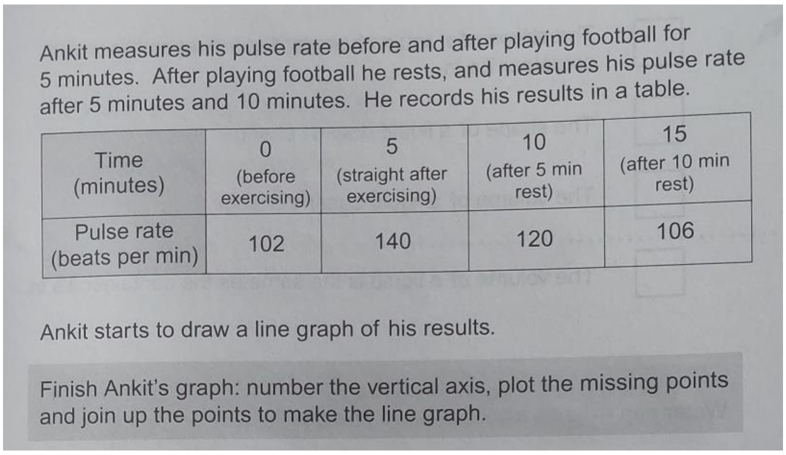
In science, pupils need to be able to use Venn diagrams and Carroll diagrams. However, these skills do not feature in the primary maths curriculum. Consequently, these skills will need to be taught explicitly in science lessons prior to being used. Once pupils can identify two or more criteria for sorting,
they can be encouraged to use these to create intersecting Venn diagrams, recognising the four areas, and also Carroll diagrams" (Primary Science Education Consultancy, 2023, p.13)

Close to home: An example of the two challenges

Intrigued by such apparent quandary, I asked my own child, who is in Year 6, if they would help me illustrate knowledge, skills, and thinking when trying to solve problems using scatter graphs and Venn diagrams. They gave consent to be involved and for me to share their ‘working out’ in diagrammatic form captured using photos. For fairness, I used questions from old Statutory Attainment Test (SATs) papers (CGP, 2007) to enable the solving of problems and to observe their working without providing any instruction. If support was required, I acted as a teacher, prompting thoughts on problem-solving using open questions.

Challenge 1: Scatter Graphs

Figure 1: *Example SATs question (CGP, 2007)*



Ankit measures his pulse rate before and after playing football for 5 minutes. After playing football he rests, and measures his pulse rate after 5 minutes and 10 minutes. He records his results in a table.

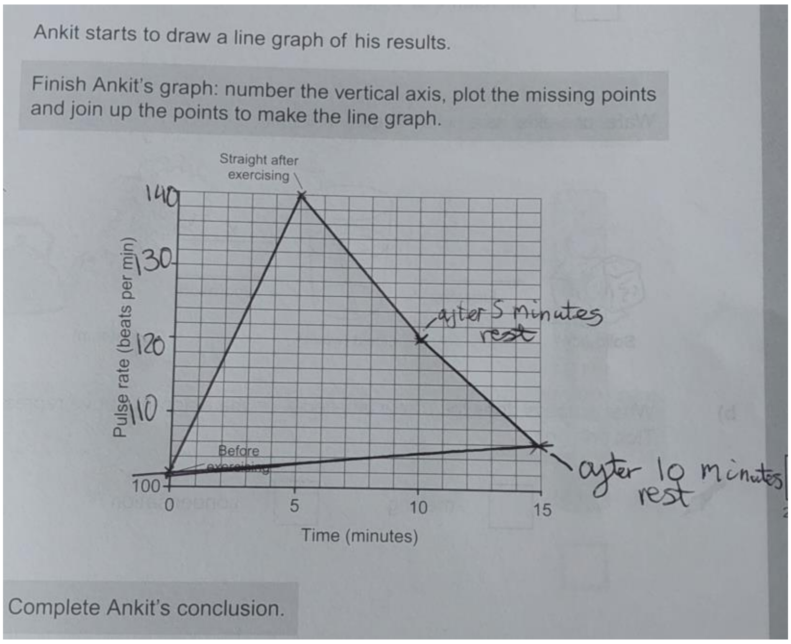
Time (minutes)	0 (before exercising)	5 (straight after exercising)	10 (after 5 min rest)	15 (after 10 min rest)
Pulse rate (beats per min)	102	140	120	106

Ankit starts to draw a line graph of his results.

Finish Ankit's graph: number the vertical axis, plot the missing points and join up the points to make the line graph.

Pupil read the question twice, and recognised in the graph outline provided, that the y-axis was incomplete and the final two data points needed to be plotted on the graph. Consideration was given to the rate at which the scale increased (2 beats per minute) and they proceeded to fill in the axis and missing data points as shown in figure 2.

Figure 2: *Scatter graph completed by Year 6 pupil (adapted from CGP, 2007)*



From the completed graph it was evident that the pupil had no problem understanding the scale of the axis and completing the missing data points; the challenge appeared to be joining the data points to create the line graph. The pupil took this joining of points literal and made a triangle, by joining the first and last data points. Reflecting on this exercise, more instruction and practice on drawing and joining up data points to construct a line graph would support the pupil's success.

Although Year 6 pupils are not required to have this knowledge until Year 7, having the knowledge and skill when analysing scientific data is useful, and a Year 6 pupil can be successful with further instruction to master this skill.

Challenge 2: Venn Diagram

I also wanted to understand if a typical year 6 pupil could complete a Venn diagram when presented with labelled hoop sorting domains, with no instruction. The hoops were labelled 'metal' and 'plastic' respectively. The pupil commenced the task by searching for objects in the environment made of either metal or plastic, as

well as objects made of both materials to place in the intersecting sorting domain space. The pupil was asked 'What do you think the area crossed over in the middle will contain?' The pupil responded 'Objects made of both [materials]'. Figure 3 shows their completed Venn diagram. The pupil enjoyed looking for objects made from plastic or metal or both and had no problem in completing the task, despite the perceived skills discrepancies between mathematics and science. This demonstrated that either the teacher had chosen to teach the prerequisite skills to construct and complete Venn diagrams as part of science learning, despite this not being a knowledge requirement in the Primary Mathematics Curriculum, and/or that having a very visual and practical hands-on science task aided the understanding and success of the pupil.

Figure 3: *Pupil's completed Venn Diagram'*

Summary

Relating my own child's experience here has demonstrated to me that trainee and in-practice teachers do need to be aware of the links and discrepancies between science and mathematics. As illustrated, there are recognised disconnects in the sequencing of some science and mathematics knowledge and skills, ultimately requiring teachers to be proactive in teaching these skills in science before they are required to be covered in mathematics. It seems unnecessarily challenging for teachers to have to sequence learning in this way as part of the existing National Curriculum because of these discrepancies. However, on a brighter note, intuitively at least, it also seems true that pupils in year 6 can be adept at tackling real-life problems and the challenges related to constructing line graphs and sorting objects using Venn diagrams. A recommendation might be that any new version of the Primary National Curriculum, pays particular attention to the knowledge required at different points in the science and mathematics curricula, and ensures that the sequence of the statutory expectations better supports year group progression. It would be ideal for there to be no disconnects or deficits in knowledge at key transition points, for example between key stages 1 and 2, and particularly between the primary and secondary phases.

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