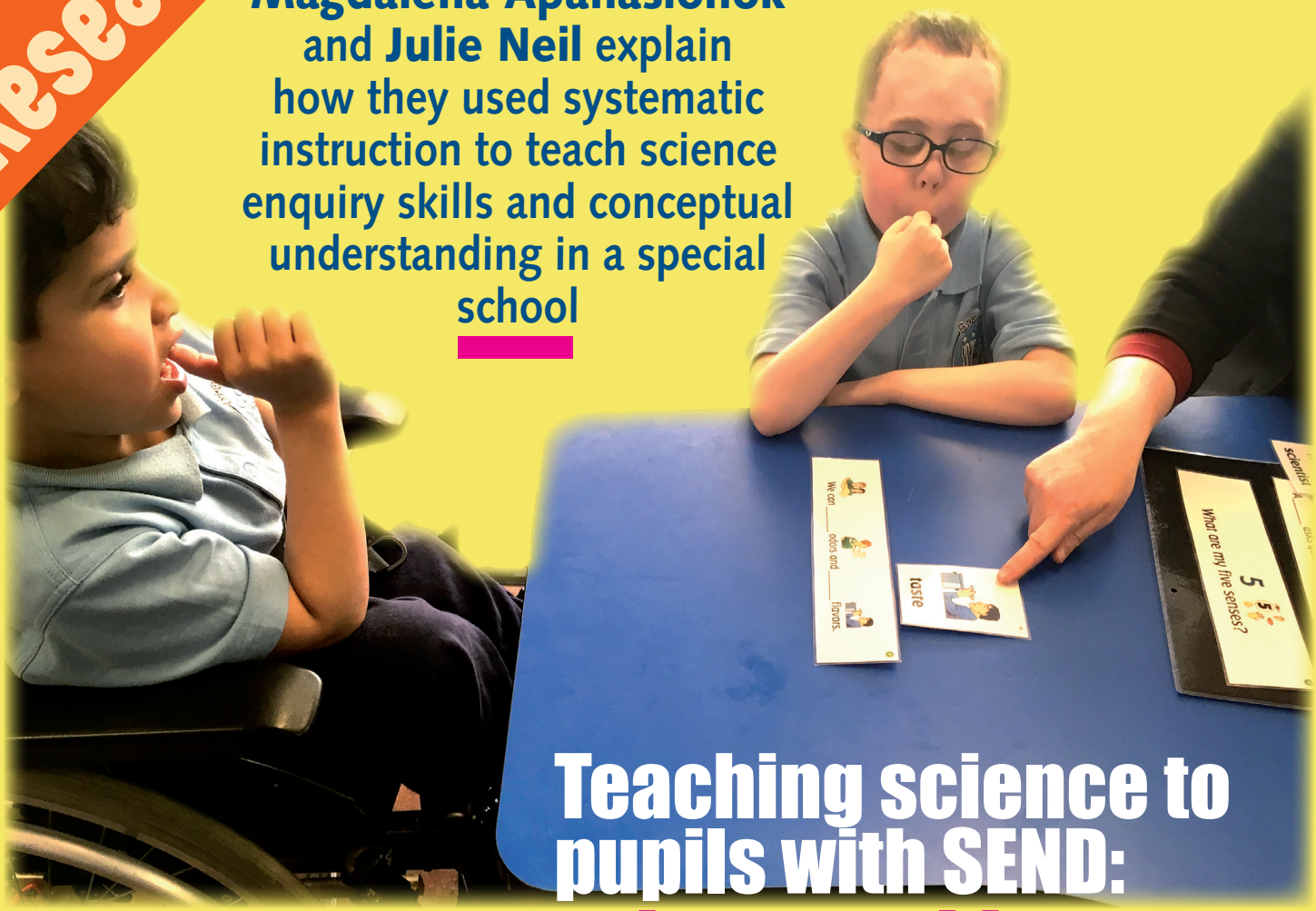
Research

Richard Watkins, Magdalena Apanasionok and Julie Neil explain how they used systematic instruction to teach science enquiry skills and conceptual understanding in a special school



Learning the concept of taste by filling out the concept statement card for the lesson on smell and taste

Teaching science to pupils with SEND: using an evidence-based approach

In their recent review of special educational needs in schools, the Education Endowment Foundation (EEF, 2020) highlights the fact that teaching strategies that we know work well for mainstream learners are also likely to be effective for pupils with special educational needs and disabilities (SEND). These strategies include:

- **flexible grouping;**
- **cognitive and metacognitive strategies;**
- **explicit instruction;**
- **using technology;**
- **scaffolding.**

Over recent years there have been a number of accessible and useful research summaries for teachers, often highlighting the effectiveness of general teaching strategies such as explicit instruction, scaffolding and task-specific feedback (Spooner, McKissick and Knight, 2017; Apanasionok *et al*., 2019; Knight *et al*., 2019), but very little research has been turned into practical classroom materials to help teachers improve the provision of science.

There is also a need to support the teaching of science to improve outcomes for pupils with SEND. In England, 14.9% of school-age children are identified as having SEND (DfE, 2019). In 2019, 42% of pupils with special educational needs (SEN) achieved the expected standard in science at the end of key stage 1 (age 7) compared to 90% of pupils with no SEN (DfE, 2020). In the same year, 22% of pupils with SEN reached the expected standard in reading, writing and maths at the end of key stage 2 (age 11) compared with 74% of their peers, and this attainment gap has remained stable since 2017 (DfE, 2020). In this article we describe how we used an evidence-based science programme called the Early Science curriculum to teach science to pupils in a special school, in particular learners with intellectual disability and/or autism spectrum disorder.

Teaching science to pupils with SEND

Over the last few decades many teachers in mainstream and special

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schools have favoured cognitive (constructivist) teaching approaches that enable pupils to build their understanding of scientific ideas by undertaking practical scientific inquiry tasks (often called inquiry-based learning). Examples of this style of teaching are common in this journal and also feature prominently in many practical guides to teaching science in primary schools (Serret and Earle, 2018).

In England, the science programme of study for key stages 1 and 2 (ages 5–11) is centred around three main aims: to help pupils develop scientific knowledge and conceptual understanding; to develop an understanding of the nature, processes and methods of science (known as 'working scientifically'); and to ensure pupils can understand the uses and implications of science (DfE, 2015). Teaching this content to pupils with SEND using inquiry or discovery-based teaching strategies can be challenging. These strategies are often successful with typically developing learners in mainstream settings, but can be less effective for less-able pupils and pupils with disabilities (Rizzo and Taylor, 2016).

Our research, focused on the existing research literature on teaching science to pupils with SEND, has indicated that science programmes using behavioural teaching strategies (e.g. systematic instruction – a teaching method focused on breaking down complex skills into smaller steps and promoting generalisation) may be an effective way to improve science outcomes (Apanasionok *et al.*, 2019).

The Early Science curriculum

The Early Science curriculum (Jimenez, Knight and Browder, 2012) uses systematic instruction approaches to teach pupils science knowledge and skills through a series of structured lessons and practical enquiry activities. It has been identified as a promising programme in several studies (Smith *et al.*, 2013; Jimenez, Lo and Saunders, 2014; Knight *et al.*, 2018; Apanasionok *et al.*, 2020) and in a systematic review (a systematic review is a higher-order literature search that critically appraises all relevant research in a given field; Apanasionok *et al.*, 2019).

The scientific content in the Early Science curriculum aligns with the elementary school science education standards in the USA (National Research Council, 2000). The curriculum consists of four units: *The five senses*, *The rock cycle*, *Earth and sky* and *The life cycle*, and we found this content aligned well with most primary science curricula in the United Kingdom. In particular, *The five senses* and *The life cycle* units fall within the key stage 1 (ages 5–7) science programme of study in England, including knowledge and conceptual understanding and scientific methods and processes (DfE, 2015). Each unit consists of seven lessons: the first six lessons introduce new topics and the seventh consolidates the content in each unit. Each lesson is repeated multiple times (at least twice) until all pupils in the class become confident with the key skills and vocabulary. Lessons consist of seven main teaching components:

- **guided inquiry;**
- **teacher scripts;**
- **a *Wonder Wally* storybook (stories with pictures to support each lesson);**
- **science safety information;**
- **explicit instruction;**
- **task analysis;**
- **special accommodations/ adjustments for the pupils, e.g. amending some of the practical tasks.**

Box 1 describes some key features of the curriculum.

Using the Early Science curriculum

We decided to work with a class of nine pupils from a primary department in a large special school to evaluate whether we could use the Early Science curriculum in a UK school setting. The learners in our study had diagnoses of autism spectrum disorder (ASD), intellectual disability (ID) and profound and multiple intellectual disabilities (PMID). The class teacher and two teaching assistants were trained in the implementation and delivery of the Early Science curriculum and supported pupils during the science lessons.

Due to time limitations, we focused only on the first unit of the curriculum: *The five senses*. We used materials included in the Early Science curriculum pack, including picture-word cards, lesson scripts, photo cards, a KWHL (What do we **K**now?, What do we **W**ant to know?, **H**ow can we find out? and What did we **L**earn?) chart, and science safety cards/resources. We gave each pupil a *My Science Log* (a set of multiple-choice quizzes implemented after each lesson to assess understanding), and the progress monitoring form included in the curriculum pack was used to monitor the progress of individual pupils.

We found we could deliver most sessions in the 40-minute time slot allocated to teaching science in the school's timetable. Each lesson started with pupils greeting a fictional *Wonder Wally* character displayed on a poster in the front of the classroom. The science teacher then introduced the main focus of the lesson and read

Box 1 Key features of the Early Science curriculum

Guided inquiry	A process of explicitly teaching inquiry skills, described by Jimenez *et al*. (2012) as teaching the learners '*how to learn about their natural world*'. It comprises five steps related to critical inquiry skills: engage, investigate, describe, explain and report.
Explicit instruction	This is an active teaching method involving time-delay procedure (prompt/help for the pupil is delivered following a specific amount of time after the instruction), most-to-least prompting procedure and an example and non-example procedure (where the pupil is presented with an example and non-example of an item which the teacher clearly labels: '*This is* …' or '*This is not* …').
Task analysis	This is a strategy whereby teachers break down a complex task into a number of smaller, more achievable steps.
Scripted lessons	Each lesson is scripted and colour-coded to increase accessibility and reduce teacher preparation time. The scripts also include expected responses from the pupils, descriptions of the practical activities and key vocabulary to be targeted for that specific lesson.

Learning the concept and key vocabulary for the lesson on touch by describing the feel and texture of a duckling and identifying the correct vocabulary card

one story from the *Wonder Wally* storybook, emphasising the key scientific vocabulary we needed to introduce. All the lessons followed the same teaching steps and focused on simple exploration tasks that allowed pupils to make simple predictions and record observations. At the end of the session, we made sure pupils were able to review their observations and discuss ideas in the context of their initial predictions. The remaining time at the end of a lesson was spent on a review of key concepts and the completion of their *My Science Logs*.

Staff and pupil feedback

We found that nearly all pupils engaged very well with the Early Science curriculum lessons. Many pupils were able to remember some of the key concepts several weeks after the lessons, something that was not typically the case with this cohort of pupils; for example, nearly all the pupils were able to recall the five senses and explain what they are. Although pupils did find some aspects of the curriculum very challenging, they all made very good progress in improving their science skills and knowledge during the course of the study (as recorded in the *My Science Logs* and unit assessment; for more information and results see Apanasionok *et al*., 2020).

We enjoyed using the Early Science curriculum as a teaching resource. The scripted lessons and the guided instruction helped learners understand new scientific knowledge and concepts and use simple enquiry skills, such as making predictions, recording observations and evaluating outcomes. Many of the teaching assistants were familiar with science sessions based on less structured enquiry and/or more sensory-approaches, so they were surprised that the pupils were clearly able to benefit from a more guided and explicit approach with a greater focus on specific science content and associated vocabulary. Teachers and teaching assistants identified the following key features as being helpful:

- **challenging pupils to pair symbols with objects;**
- **using time-delay strategy;**
- **using exemplar and non-exemplar procedures;**
- **the predictable structure of the lessons.**

Does the Early Science curriculum fit into a UK school setting?

Although this curriculum was designed in the United States and referenced to their elementary science standards (National Research Council, 2000), we did not find any significant problems adapting it for use in a UK

Box 2 Issues arising and solutions

Aspect to improve	How could it be improved?
Time	Allow more time for lessons and practical activities. Although each lesson in the school was 45 minutes, by the time the pupils arrived in the science classroom there was only 35–40 minutes remaining. This could perhaps be achieved by delivering each lesson in two sittings/sessions.
Staffing ratios	The class was divided into two groups of pupils, with each assigned a teaching assistant. It was important to retain these two teaching assistants alongside the science teacher to help deliver individualised instruction and prompts.
Supporting pupils to record findings	At times it was a challenge to ensure that all pupils received support and guidance to help them complete their *My Science Log*. The science teacher made every effort to ensure there were two members of staff present during most sessions to support individual pupils.
Practical tasks	At times it was necessary to amend or change the nature of the practical tasks in the lesson plans (because of the lack of resources or other practical limitations). We found it was always possible to substitute a similar task to achieve the learning outcomes.

Pupils filling out *My Student Log* at the end of the lesson to summarise what they have learned

special school. The only issues we noted were time limitations and lack of staff to support some of the more challenging pupils during practical sessions, assisting them to complete their science logs and unit assessments (needed because of difficulties in communicating their ideas and observations), and the need to adjust the nature of some of the practical tasks (Box 2). However, none of these issues prevented us from successfully using the Early Science curriculum.

Conclusions

The pupils in our study enjoyed learning science using the Early Science curriculum. We found that it was possible to use the lesson plans and resources in a UK special school setting, and the teaching units and lessons were well matched to the science programme of study in England. Along with the vast majority of teachers in the UK, staff in this special school had previously employed enquiry- and/or sensory-based strategies to teach science. The evidence and feedback from this study is that programmes built around more explicit/systematic instructional approaches are likely to offer a more promising approach to teaching science to pupils with SEND, including successfully teaching relevant scientific knowledge and inquiry skills to enable learners to work scientifically.

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References and further reading

Apanasionok, M. M., Hastings, R. P., Grindle, C. F., Watkins, R. C. and Paris, A. (2019) Teaching science skills and knowledge to students with developmental disabilities: a systematic review. *Journal of Research in Science Teaching*, **56**(7), 847–880.

Apanasionok, M. M., Neil, J., Watkins, R. C., Grindle, C. F. and Hastings, R. P. (2020) Teaching science to students with developmental disabilities using the Early Science curriculum. *Support for Learning*. DOI: 10.1111/1467-9604.12329.

DfE (2015) *National Curriculum in England*: *Science programmes of study: key stages 1 and 2*. London: Department for Education. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/425618/PRIMARY_national_curriculum_-_Science.pdf

DfE (2019) *Special educational needs in England: January 2019*. London: Department for Education. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/814244/SEN_2019_Text.docx.pdf

DfE (2020) *Special educational needs and disability: an analysis and summary of data sources*. London: Department for Education. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/882802/Special_educational_needs_and_disability_-_an_analysis_and_summary_of_data_sources.pdf

EEF (2020) *Special educational needs in mainstream schools: five recommendations on special education needs in mainstream schools*. London: Education Endowment Foundation. Available at: https://educationendowmentfoundation.org.uk/tools/guidance-reports/special-educational-needs-disabilities

Jimenez, B., Knight, V. and Browder, D. (2012) *Early Science curriculum*. Verona, WI: Attainment Company.

Jimenez, B. A., Lo, Y. and Saunders, A. (2014) The additive effects of scripted lessons plus guided notes on science quiz scores of students with intellectual disability and autism. *Journal of Special Education*, **47**(4), 231–244.

Knight, V. F., Collins, B., Spriggs, A. D., Sartini, E. and MacDonald, M. J. (2018) Scripted and unscripted science lessons for children with autism and intellectual disability. *Journal of Autism and Developmental Disorders*, **48**(7), 2542–2557.

Knight, V. F., Wood, L., McKissick, B. R. and Kuntz, E. M. (2019) Teaching science content and practices to students with intellectual disability and autism. *Remedial and Special Education*, 1-14. DOI: 10.1177/0741932519843998

National Research Council (2000) *Inquiry and the National Science Education Standards: a guide for teaching and learning*. Washington, DC: National Academies Press.

Rizzo, K. L. and Taylor, J. C. (2016) Effects of inquiry-based instruction on science achievement for students with disabilities: an analysis of the literature. *Journal of Science Education for Students with Disabilities*, **19**(1), 1–16.

Serret, N. and Earle, S. (2018) *ASE guide to primary science education*. 4th edn. Hatfield: Association for Science Education.

Smith, B. R., Spooner, F., Jimenez, B. A. and Browder, D. (2013) Using an Early Science curriculum to teach science vocabulary and concepts to students with severe developmental disabilities. *Education and Treatment of Children*, **36**(1), 1–31.

Spooner, F., McKissick, B. R. and Knight, V. F. (2017) Establishing the state of affairs for evidence-based practices in students with severe disabilities. *Research and Practice for Persons with Severe Disabilities*, **42**(1), 8–18.

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