

Development and evaluation of neuroscience lesson content to improve Key Stage 3 (11–14 year old) students' understanding of the early years in England

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Abstract

The Oxford SEEN (Secondary Education around Early Neurodevelopment) project developed Key Stage 3 (11–14 year olds) science lesson content about the importance of the early years for lifelong health and evaluated its impact on students' knowledge of the neuroscience and practical application to a real-world scenario. A mixed methods approach was used collecting quantitative and qualitative data from students and staff using pre- and post-lesson surveys and focus groups. Data were analysed from 2767 students from 20 schools in England. The new curriculum successfully increased both student's scientific understanding and practical application of knowledge about neurodevelopment and the role of the caregiver. Students' mean multiple choice question scores (assessing knowledge) were higher post-lesson compared to pre-lesson; this increase was consistent across gender and year group. The post-lesson and 6–8-week follow-up scores were similar, indicating a retention in students' knowledge. Students were also asked how they would care for a 2-year-old child to promote brain development; before the lessons 89% of students provided no or a basic level answer, but after the lessons 50% of students provided detailed or advanced comments. The lessons were feasible and acceptable; both teachers

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and students stated the curriculum should be taught to other students. Qualitative analyses indicated that the lessons inspired the curiosity of both teachers and students and were perceived to impact on students' interaction with children in their current lives and their future career choices. The Oxford SEEN curriculum could serve as a foundation to build community-wide knowledge about the importance of the early years, with the aim of enhancing mental and physical health outcomes for future generations.

KEYWORDS

curriculum development, impact evaluation, science, secondary schools

INTRODUCTION

The first 1001 days (pregnancy and the first 2 years of a child's life) are a critically important period for human development that significantly influence a child's long-term health, well-being, learning and earnings potential (Department of Health and Social Care, 2021). During this sensitive time the brain grows rapidly (proliferation) followed by the selective removal of unused connections (pruning), resulting in a period of heightened neuroplasticity. Experiences such as those between an infant and their caregiver will determine the foundational brain networks that develop during this time. The early years provide the foundation for children's nascent emotional well-being, resilience and adaptability.

From birth, a baby is primed for social interactions with a caregiver who will respond positively to their cues. Sensitive and responsive parent–infant relationships have been shown to be pivotal for the development of infants' social, emotional, behavioural and cognitive skills (Eshel et al., 2006). Three core caregiver capacities are critical for different aspects of child development: (i) The caregiver's focus of attention to child signals and associated contingent responsiveness (Serve and Return (AFWI)) is essential for the development of the child's cognitive ability (Mills-Koonce et al., 2015). Contingent responses to the infant teach the infant about connections between stimuli and responses and help establish and develop the infant's own attentional skills (Bornstein et al., 2014) (ii) Emotional scaffolding or caregiver support (particularly in times of infant distress) play a key role in promoting infant emotional regulation, principally through warmth, consistent support and low levels of intrusiveness and coercion during stressful situations (Haley & Stansbury, 2003). This is key for the development of the child's own emotional regulation skills and behaviour (iii) 'Sensitivity', generally defined as parental availability and appropriate responsiveness to the infant, has been shown to be an important predictor of attachment (Fonagy & Target, 1997; Meins et al., 2001). Two key related concepts are (i) 'reflective functioning' which refers to the caregivers' ability to hold both their own thoughts and feelings about a situation, while attempting to simultaneously understand their child's feelings and behaviour (Fonagy & Target, 1997) and (ii) parental 'mind-mindedness' which refers to a caregiver treating the infant as having their own thoughts, feelings and 'their own mind' (Meins et al., 2001).

The implications of a child's experiences during their early years are far reaching both for the individual and for society. The impact of early adversity results in deficits which reduce adults' subsequent productivity and increase social costs (Berens et al., 2017; Hughes et al., 2017). Research has consistently identified that exposure to adverse childhood

experiences (Felitti et al., 1998) is associated with an increased risk of poorer outcomes across physical, mental and social health domains for children and adults (Shonkoff et al., 2012).

Action is urgently needed to embed a universal understanding of the role of the caregiver and early experiences on children's brain development and subsequent long-term outcomes. This foundational knowledge is essential to equalise future opportunities for all children, enabling them to achieve their full potential (Shonkoff & Bales, 2011). The Oxford SEEN project aimed to contribute to this goal by evaluating the impact of teaching children aged 11–14 years (Key Stage 3 (KS3)) about neuroscience and influences on the developing brain.

In England, science is included as a core subject in the National Curriculum which sets out the programmes of study and attainment targets which must be taught by local authority-maintained schools (Department for Education, 2013a). The stated aims of science education for students include 'learn about its uses and significance to society and their own lives' and 'provide the foundation for a range of diverse and valuable careers that are crucial for economic, environmental and social development' (Department for Education, 2021). The National Curriculum for science in England incorporates core health messages, for example a healthy human diet (including consequences of dietary imbalances and deficiencies); the effects of recreational drugs; the effect of maternal lifestyle on the developing foetus via the placenta (Department for Education, 2013b). However, the key processes of brain development during the Early Years (including neural proliferation and pruning and the influence of social and emotional experiences) are not currently included.

Science is mandatory for all Key Stage 3 (KS3) students and therefore offers an opportunity for a universal intervention to equip the next generation with a scientific understanding of why the early years matter. Although science remains compulsory at Key Stage 4 (KS4), the choice of curriculum is more varied with core and single science GCSE awards.

There is a body of work relating to pedagogical approaches to teaching science (Magaji et al., 2018; Potvin et al., 2020) and the evaluation of novel, school-based programmes (taught by teachers). These include (1) quantitative questionnaires and qualitative focus groups to assess improvements in student's knowledge, beliefs and understanding of climate change after 10 lessons (Kurup et al., 2021) (2) the MYRIAD trial, which aimed to teach adolescents mindfulness skills to improve mental health. This randomised controlled trial required a whole school approach with staff undergoing extensive training (more than 8 weeks) and considerable time commitments; no changes in student mental health were found (Kuyken et al., 2022) (3) the sleep health promotion programme Teensleep which measured the effectiveness of a 10-lesson programme on students' knowledge of sleep, sleep quality, hygiene and quality of life (Illingworth et al., 2020). Comparison of pre- and post-scores indicated a large improvement in sleep knowledge (assessed by the study author-devised 20 question multiple choice quiz), with smaller positive changes in sleep quality and hygiene (assessed by validated questionnaires) (Illingworth et al., 2020). To our knowledge, there have been no studies which have evaluated change in student knowledge or application following the introduction of new lesson content specific to neurodevelopment into KS3 science curriculum. Given the pressures on teaching time and resources, it is vital that new initiatives are evaluated to ensure they are implementable and achieve their objectives.

The Oxford Secondary Education around Early Neurodevelopment (SEEN) project aimed to develop science lesson content for KS3 students and evaluate its effectiveness at increasing students' understanding of early neurodevelopment and practical application. The secondary aims were to determine whether the lessons were feasible and acceptable to both teaching staff and participating students.

MATERIALS AND RESEARCH METHODS

Design of the Curriculum

The curriculum content was based on the research team's internationally recognised academic expertise and refined in collaboration with advisory group consultations (November 2020–March 2021). An academic advisory group comprised of world leading experts determined the key concepts and neuroscientific research to be included in the curriculum. The lesson resources were drafted by a member of the research team with 15 years of experience in secondary school science teaching. The resources reflected good practice guidance for science teaching, including the explicit teaching of important vocabulary; activities to identify and address misconceptions; the scaffolding of learning using carefully sequenced explanations and models; and flexibility was incorporated to enable teachers to adapt the materials for their students (Holman & Yeomans, 2018). Teachers were also provided with an information pack and short training film to support their planning, professional development and appropriate placing of the content into their science curriculum to ensure learning progression. An advisory group of educational leaders including a member from the Department for Education were consulted about the draft content and resources, and the steps necessary for successful implementation into schools. The lesson resources were trialled with six schools and modifications made based on feedback from teachers and students.

Curriculum content

The themes for the curriculum in [Table 1](#) were agreed through meetings and discussion with members of the advisory groups.

Lesson content

The 10 themes were developed into three lessons. Additional lessons, homework and revision sessions were also created to extend and reinforce learning. The content for each lesson was as follows:

Lesson 1—Brain development in the early years: The neuroscience that underpins child development including the rapid proliferation of neurons following conception. Both genes and the environment affect brain growth in the early years (AFWI). Connections are made between neurons as babies are exposed to new experiences. Connections are strengthened or weakened depending on a baby's experience. The ability of the brain structure to change based on experiences, also termed neuroplasticity.

Lesson 2—Caregivers and the early years: The key influence of caregivers on babies' day-to-day experiences. Caregivers' actions directly affect brain development and can ensure healthy brain development during the sensitive early years (conception to 5 years). Key behaviours include responsive caregiver–child interactions (AFWI), baby talk (Infant Directed Speech) and playful learning. Practical application of this knowledge and skills. Extension or optional homework activity about development of executive function skills.

Lesson 3—Brain development throughout life: Research from longitudinal studies show the importance of the early years for long-term health outcomes. The early years are not deterministic, and adolescence is another sensitive period for brain development. Supportive relationships and the development of executive function skills can improve resilience at any life stage (AFWI). The early years remain the most effective period for improving outcomes.

TABLE 1 Learning themes for the Oxford SEEN curriculum.

1. Neural architecture	The brain is made up of billions of interconnected neurons
2. Nature and nurture	Genetics and environment both have a role to play in brain development; epigenetics means that even the genes are not fixed
3. Learning and memory	New experiences can lead to new neural circuits being formed. Circuits can be strengthened and weakened by individual experiences
4. Neuroplasticity	The ability of the brain to change throughout a person's life is called neuroplasticity
5. Developmental windows	The brain is particularly plastic, and therefore sensitive to experiences, in the early years (0–5) and adolescence (11–25)
6. Early neurodevelopment	Essential neural pathways are developed in the uterus and throughout the early years. Babies perceive and discriminate environmental stimuli in the uterus and during early life
7. The role of caregivers	Caregivers can improve long-term health outcomes by supporting brain development in the early years through: a. Responsive, reciprocal caregiver–child interactions (Serve and Return (AFWI)) b. Baby talk or 'Infant Directed Speech' c. Playful learning d. d. Developing executive function skills
8. The evidence for early years and health outcomes	The early years are a foundation for long-term physical and mental health
9. Behavioural change	What happens in the early years is not deterministic
10. Responding to adversity	Resilience is dependent on supportive relationships and developing skills (AFWI)

Materials

The lessons were designed to be delivered by classroom science teachers. Specific knowledge of neuroscience and the early years was not required; a teacher training pack was developed to support teachers in delivering the lessons. The pack included a pre-recorded online training session, background to the content and support for lesson planning. Teachers were also offered live online training on request. It was essential that the lessons could be delivered in a variety of ways due to the COVID-19 pandemic; this included classroom or online delivery by teachers, or independent learning through pre-recorded lessons. The curriculum materials were designed for maximum flexibility; core content was provided in a non-PDF format so teachers could amend as necessary and choose worksheets and activities depending on the delivery format and age or ability of the students. This flexibility ensured high quality delivery as teachers tailored materials appropriate for their class and context. The materials were publicly available to view and download from the <redacted>.

The curriculum materials included (A) For the Teacher: (1) project description and rationale, (2) core content summary, (3) overview of lessons and resources, (4) lesson plans, (5) electronic links to evaluation surveys (plus back up printable version), (6) keyword lists, (7) information about safeguarding young people, (8) cross-curricular links, (9) implementation advice for coordinating teachers, (10) extension and differentiation materials and (11) additional sources of information including research papers; (B) Lessons: (1) PowerPoints (including links to publicly available films and animations e.g., <https://www.albertafamilywellness.org/resources/video/brains-journey-to-resilience>), (2) worksheets (foundation, higher and extension) and (3) pre-recorded lessons and accompanying student pack for delivery without a teacher.

Guidance for teachers, classroom activities, extension resources and examples of students work are available on request.

Recruitment of schools

A recruitment advert with a link to the Oxford SEEN project website (<https://www.psych.ox.ac.uk/research/seen>) was tweeted by the University of Oxford Department of Psychiatry (@OxPsychiatry), Medical Sciences Division (@OxfordMedSci) and Child and Adolescent Psychiatry (@OxChildPsych) accounts, in addition to the project's funder, Kindred2 (@KindredSquared). The advert was shared with the personal teaching networks of research team members and circulated via email to Head teachers from Oxfordshire, Gloucestershire and Wiltshire secondary schools. The Expert Advisory Groups and Kindred2 were also asked to share recruitment information with their professional networks. Additionally, information was circulated through a leading education newsletter (The Key). The Oxford SEEN project website included an introductory video about the project and an email address for schools to register their interest in taking part.

Data collection

Lessons were delivered by students' science teachers and data were collected (online using JISC surveys or on paper forms, depending on school preference) between March 2021 and September 2021. Demographic data including year group, gender, school, class, teacher and delivery type was gathered from each student. No other student data were collected (i.e., student name).

Surveys (online or paper) were completed to assess students' knowledge using 10 multiple choice questions (MCQ) (Table 2) and their practical application of the lesson content using a short answer question about how they would care for a 2-year-old child to promote brain development:

'Imagine you are asked to help look after a friend's 2-year-old child for the day. Explain what you can do to support the child's brain development as you play together. Give three different examples. You can write "I don't know" if you need to'.

The surveys were administered pre, post and 6–8 weeks after completion of the lessons.

Experience of the lessons

A mixed methods approach was employed to explore participants' experience of delivering or receiving the Oxford SEEN lessons and to contextualise the quantitative results. Teachers and students were asked to complete quantitative surveys and short answer questions (online using JISC surveys or paper forms).

Teachers and students were invited to participate in focus group discussions which followed a semi-structured format lead by the research team (Appendix). The group discussions took place online and were audio recorded. 18 teachers representing 12 different schools, and 14 students from two different schools took part. The duration of group discussions ranged from 45 to 60 minutes.

TABLE 2 Multiple choice questions in student survey.

Multiple choice questions	Answer options
1. What is the name of nerve cells in the brain?	(a) Axons (b) Epithelial cells (c) Neurons (d) Lymphocytes (e) I don't know
2. Which of the following is the best definition of neuroplasticity?	(a) The brain changes in size as a child grows (b) The fixed structure of the brain during a person's life, which is not changed by their experiences (c) Different parts of the brain are responsible for different functions, tasks or skills (d) The brain's ability to change and grow during a person's life because of their experiences (e) I don't know
3. How do experiences shape the structure of the developing brain? <i>Select all the answers that are correct</i>	(a) They increase the number of neurons in the brain (b) They influence which neural connections are strengthened and which are pruned away (c) They decrease the number of connections between neurons (d) They increase the number of connections between neurons (e) I don't know
4. Why is it important for a caregiver to communicate and respond to their child with their voice, eye contact or touch? <i>Select all the answers that are correct</i>	(a) It helps the baby's brain to develop and grow (b) It develops the relationship between the child and caregiver (c) It helps the baby to learn how to concentrate (d) It helps the baby to learn about how to take turns (e) I don't know
5. When do children start playing a role in conversations?	(a) When they are old enough to make recognisable words (b) From birth (c) When they can speak in whole sentences (d) When they start to make babbling sounds (mamama or dada or bububu) (e) I don't know
6. How should a caregiver speak to a baby? <i>Select all the answers that are correct</i>	(a) They should speak fast (b) They should exaggerate their facial expressions (make their facial expressions very clear and obvious) (c) They should use a sing-song tone of voice (d) They should make their speech as complicated as possible (e) They should keep repeating the same words (f) I don't know
7. At what age do you think a child's brain is developing fastest?	(a) Start of pregnancy to 2 years (b) 3–5 years (c) 6–10 years (d) 11–15 years (e) Develops evenly throughout childhood until adulthood (f) I don't know
8. Which of the following affects how children develop during their first 5 years of life?	(a) A child's genes (b) A child's environment (where they live, who looks after them and their everyday experiences) (c) A combination of both their genes and environment (d) Neither their genes nor their environment (e) I don't know
9. When is the brain most sensitive to experiences?	(a) 0–5 years (b) 0–5 years and 11–25 years (c) 0–5 years and 10–15 years (d) 0–25 years (e) Throughout life (f) I don't know
10. Which of the following has/have an impact on an individual's resilience? <i>Select all the answers that are correct</i>	(a) Their genes (b) The number of people that can support them (c) The number of difficult situations that they experience (d) Having a safe learning environment (e) I don't know

Quantitative data analysis

Data were analysed for 2767 students, attending a school in England and for whom the Oxford SEEN lessons were delivered within science lessons. A further 293 students took part in the lessons as part of Personal, Social and Health Education (PSHE), and 173 students were outside of England.

Students' knowledge: MCQ

Students could score a maximum of 10 points in the 10 MCQs in the survey with each question being worth a total of one point. Each question had five or six potential answers including 'I don't know'. For questions which had one correct answer, selecting the correct answer and no other options gave the participants a score of one for that question. Questions 3, 4, 6 and 10 had multiple correct answers and were scored proportionally. For all questions, if a participant selected an incorrect answer, they received 0 points for that question.

Students' application of their knowledge was assessed using the marking scheme outlined in Table 3. The marking scheme was developed by the authors of the study and a subset of students' responses were double marked by authors LA and EL-N to ensure consistency.

Numerical data were analysed using Excel, SPSS and R.

Qualitative data analysis

Audio-recordings of the focus group discussions were transcribed verbatim and verified by the research team. Reflexive thematic analysis guided the qualitative analysis (Braun & Clarke, 2006, 2021). Initially, a subgroup of authors read and re-read the transcripts to gain a sense of each participant's story. Deployed as an inductive method, codes were developed by marking similar phrases or words in the narratives. <redacted> undertook an analytical mind mapping process to explore patterns and relationships in the data and to identify themes. These outputs were separately analysed by <redacted> and <redacted>. Final themes were verified and refined through critical dialogue.

Pilot study

The lessons were piloted in six schools between January 2021 and March 2021; from this pilot some minor changes to the lesson resources and activities, and revisions to the wording of the multiple choice questions for students and teacher surveys were made (available on request).

TABLE 3 Short answer question marking scheme.

0–2 marks	3–4 marks	5–6 marks
Appropriate basic comments made	3 marks=At least 1 appropriate detailed comment made or a correct explanation of why something is being done	3 different detailed comments given (or 2 very advanced level). These are likely to included explanations of why something is done OR an indication that the child has understood a broad range of topics covered in the lessons
0 marks if only 1 basic comment given	4 marks=3 detailed comments made. One comment may include advanced language, for example baby talk. Or a link to why you are doing something	5 marks=at least 2 refer to advanced levels of knowledge
1 mark if only 2 comments given		6 marks=All three comments have advanced explanation or language
Keep at 2 marks even if 3 comments made, but all at basic level		

Ethical considerations

This project was reviewed by the University of Oxford/Oxford University Hospitals Joint Research Office Study Classification Group, which determined that it was a service (curriculum) development, not an activity requiring research governance.

Patient and public involvement statement

Members of the public were not involved in the study. We received input from teachers, educational advisors and researchers in the design of the materials. We intend to disseminate the main results to teachers and advisors who participated.

RESULTS

Demographics

Participating schools

Twenty schools of varying types (Table 4) participated in the project across 15 different counties of England (Table 5).

Demographics of participating students

The total number of students who participated in the lessons was 3233 and data were analysed from 2767 students. The proportion of the schools' students eligible for pupil premium ranged for 10.0%–56.7%, with a mean of 29.4% (data were unavailable for the participating four independent schools). A breakdown of the student demographics is shown in Table 6.

Quantitative results

Scientific knowledge

Students' scientific knowledge was measured by their answers to 10 MCQs in the surveys at each time point. Mean scores were calculated for each student; there was an increase in the

TABLE 4 Type of participating school and number of survey responses.

School type	<i>n</i>	Pre-lesson survey (<i>n</i>)	Post-lesson survey (<i>n</i>)	Follow-up survey (<i>n</i>)
Academy Converter	8	1303	944	813
Academy Sponsor Led	5	1003	777	383
Independent School	4	99	85	15
Community School	1	143	17	0
Free School	1	160	184	0
Foundation School	1	59	49	0

TABLE 5 Location of participating schools by county.

County	<i>n</i>
East Sussex	1
Wiltshire	1
Oxfordshire	4
North Yorkshire	2
Essex	1
Lancashire	2
Herefordshire	1
Greater London	1
Cheshire	1
Shropshire	1
Tyne and Wear	1
West Midlands	2
Kent	1
Hertfordshire	1

TABLE 6 Demographics of participating students.

Student category	Student subcategory	<i>n</i>
Combined data	All data	2767
Gender breakdown	Females	1286
	Males	1220
	Other/Prefer not to say	261
Year group breakdown	Year 7	1377
	Year 8	1048
	Year 9	339

mean scores at the post-lesson time point compared with the pre-lesson time point indicating an increase in scientific knowledge (Table 7 and Figure 1). This increase was consistent when the scores were analysed by gender, year group and mode of survey completion (online or paper) (Table 7). The scores immediately after the lessons and at 6–8-week follow-up were similar, indicating a retention in students' knowledge.

Students showed the greatest increase in their knowledge for questions relating to the name of a nerve cell in the brain (Q 1), the definition of neuroplasticity (Q 2), how a caregiver should speak to a baby (Q 6) and the age at which a child's brain is developing fastest (Q 7) (Figure 1).

Regression analysis

Multiple linear regression was used to investigate predictors of change in the MCQ scores from pre-lesson (baseline) to post-lesson. The following variables were examined in the regression: School year, gender and delivery modality. Gender for 'unknown' groups was omitted. The overall regression was statistically significant ($R^2=0.2802$, $F(7, 123)=6.84$,

TABLE 7 Mean MCQs for students at pre, post and follow-up time points.

Student category	Subcategory	Pre-lesson		Post-lesson		Follow-up lesson	
		<i>n</i>	MCQ mean score	<i>n</i>	MCQ mean score	<i>n</i>	MCQ mean score
Combined data	All data	2767	3.09	2056	4.78	1211	4.28
Gender breakdown	Females	1286	3.11	952	4.99	553	4.46
	Males	1220	3.14	868	4.69	549	4.10
	Other/Prefer not to say	261	2.78	236	4.31	109	4.28
Year group breakdown	Year 7	1377	3.01	1065	4.45	760	4.16
	Year 8	1048	3.09	808	4.93	451	4.48
	Year 9	339	3.39	182	6.08	No data	No data
Mode of survey completion	Online	1331	3.48	975	5.21	407	4.63
	Paper	1436	2.74	1081	4.40	804	4.10

$p=0.000$). It was found that school year significantly predicted improvement in MCQ scores (Year 8, $\beta=[0.739961]$, $p=0.000$, Year 9, $\beta=[1.905247]$, $p=0.000$). Gender and delivery modality did not significantly predict improvement in MCQ scores.

A second multiple linear regression was used to investigate predictors of change in the MCQ scores from pre-lesson to 6–8-week follow-up assessment. The same variables were examined. The overall regression was statistically significant ($R^2=0.2036$, $F(6, 77)=3.28$, $p=0.0063$). However, school year no longer significantly predicted improvement in MCQ scores (year, $\beta=[0.2873407]$, $p=0.221$). The other variables did not significantly predict improvement in MCQ scores either.

Application of knowledge

The student surveys also included a short answer question:

‘Imagine you are asked to help look after a friend's 2-year-old child for the day. Explain what you can do to support the child's brain development as you play together. Give three different examples. You can write “I don't know” if you need to’.

Before the lessons 89% of students provided no answer or a basic level answer (1–2 points using the mark scheme outlined in Table 3). After the lessons 50% of students provided detailed or advanced comments to score in the two highest marking brackets (3–6 marks). These students demonstrated knowledge and understanding beyond what would be expected using everyday experiences or common sense and articulated the link between their practical knowledge and the core science of why these activities were so important (Figure 2).

Examples of students' advanced-level responses included:

- *Use eye contact when talking*
- *Speak in a slow voice with exaggerated expressions so that the baby can understand better; repeat and emphasise key words in a sentence to expand the baby's vocabulary*

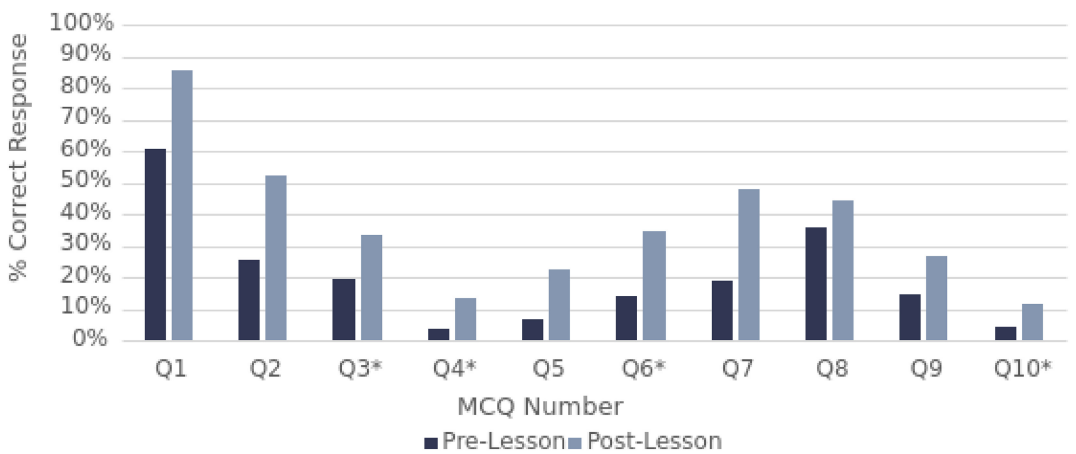


FIGURE 1 Pre-lesson and post-lesson MCQ scores by question. Questions requiring multiple correct answers to achieve 1 mark are indicated with an asterisk.

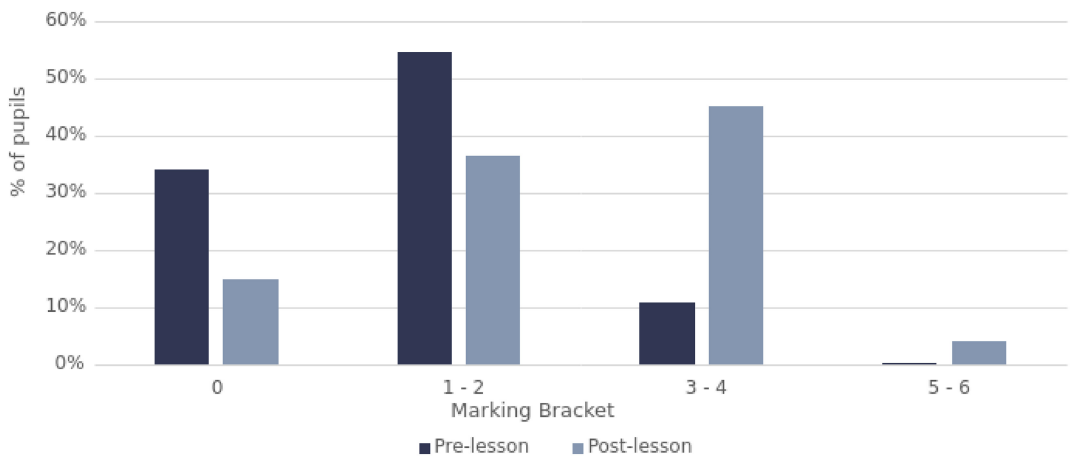


FIGURE 2 Percentage of students within each marking bracket for the application of knowledge question.

- *Start by playing how they want to play. Then start narrating your play and telling them the names of the different things they are playing with. Repeat your words slowly and help them by taking turns*
- *I would encourage them to play games with me, taking turns while still providing them with the opportunity for self-discovery*

Feasibility and acceptability of the Oxford SEEN lessons

The post-lesson surveys included questions investigating the feasibility and acceptability of the curriculum content for students and teaching staff.

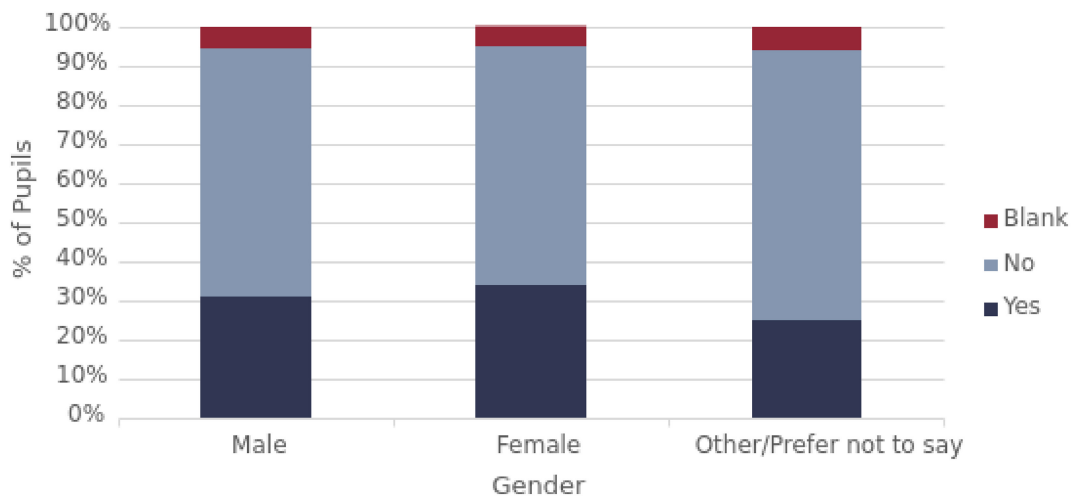


FIGURE 3 Percentage of students reporting that they had shared an element of the lesson by gender.

Students

A third of students ($n=631$) reported sharing an element of the lesson content with someone outside of their class. This was similar across self-identified genders (Figure 3). The majority of these students ($n=496$) stated they had shared this new knowledge with their parent or carer.

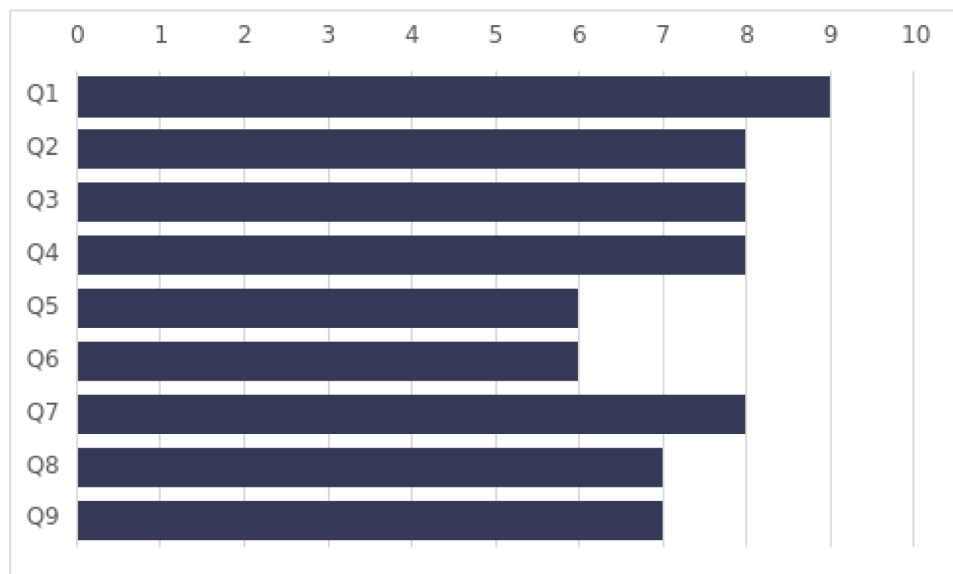
Of the 1918 students who answered the post-lesson survey question ‘*Should students of the same age in other schools should be taught the SEEN lessons?*’ 91% responded ‘Yes’. Of those students who did not agree others should be taught the Oxford SEEN lessons, 133 gave a reason for this opinion, with 34.6% ($n=46$) of comments reflecting a belief that the content would be more relevant for older learners who might be closer to having children themselves.

Teachers

Teachers were asked to rate their experience of the Oxford SEEN project materials and lesson delivery using 10-point Likert scales (0–10 with 10 being the most positive). 45 teachers completed the survey; the modal rating for the resources and Oxford SEEN project was 6 or above for all categories, as shown in Figure 4.

Teachers were asked to rate how challenging they found the lesson content for their students using a 10-point Likert scales. The mean score for each lesson was 6 (with 5 being the right level of challenge; 0 being not at all challenging and 10 far too challenging). Teachers rated each of the three lessons for their level of interest to their students (0 being not at all interesting and 10 being extremely interesting); the mean score for each lesson was above 7.

Teachers were asked ‘*Do you think brain development during early childhood should be covered in school?*’ All (100%) of the teachers who completed the survey stated that they believed this **should** be part of the curriculum, with the majority (80%) reporting that this should be within science.



Question 1	Teacher pack was comprehensive and clear
Question 2	I had sufficient knowledge to deliver the lessons
Question 3	Teaching resources were easy to access
Question 4	Resources appropriately pitched for a KS3 lesson
Question 5	Students were engaged in the activities
Question 6	Materials flexible enough for easy differentiation
Question 7	Lessons were about the right length
Question 8	Lessons could be delivered in variety of ways (in class/online)
Question 9	I would recommend the resources to other teachers

FIGURE 4 Teachers' modal ratings of the project materials and resources.

Qualitative results

Eighteen teachers participated in focus groups, and 40 completed a qualitative teacher feedback survey. 14 students participated in focus groups with their peers. These discussions aimed to explore teachers' and students' attitudes to, and experiences of the Oxford SEEN lessons. Overall three themes were identified (1) impact of lesson content on students' knowledge and attitudes, (2) opportunity to share lived experience and (3) relevance to the KS3 science curriculum.

Theme 1: Impact of lesson content on students' knowledge and attitudes

Most teachers provided positive feedback about the Oxford SEEN materials, lesson plans, resources and training, describing them as '*fantastic*,' '*informative*' and '*completely sufficient*'. Many teachers reported how well received the animations and short films provided in the lessons were by the students especially the Journey to Resilience film created by AFWI. Teachers enjoyed teaching novel content to the students and reflected that it had prompted them to '*think outside the box*' as educators. The perceived relevance of the Oxford SEEN lessons meant that some teachers reported extending the number of lessons they used to cover the content, either because the enthusiastic group discussions meant the lessons took longer than expected or because they wanted to further develop the themes introduced in the earlier lessons.

Some students reported that the material was '*hard to learn*' and had initially felt that the content was not relevant to them, particularly if they were not planning to have children in the future. However, many students recognised that the lesson content would be relevant for future parenting skills so that parents would '*know what to do*'.

Teachers reported that their students could still remember many aspects of their early childhood and how they were parented; this allowed them to use their own experiences during class discussions. Teachers reflected that the Oxford SEEN lessons had '*inspired*' their students to think about A-level and GCSE subject choices as well as future careers such as scientific research, teaching or childcare. Teachers perceived that teaching students about cognition and memory helped students understand how brains can '*learn best*' when in a school environment.

'They enjoyed it because I could apply it to their actual education'. Teacher 12

Sub theme 1: Skill development. Teachers described how the lesson content had helped students develop skills in interacting with young children and infants and how the importance of these interactions. They reflected that the lessons had prompted their students to think about the behaviours of their siblings, cousins or other children in their lives.

'They feel they could have an impact on the development of a child, rather than it being an adult's job'.

Teacher 4

Students shared examples of how an understanding of neurodevelopment could be used in real life situations and gave examples of how caregivers' behaviour could affect children:

'...try not shout at the baby as it could damage their [baby's] mental health'.

Student 3

Students reported telling their caregivers about how '*baby talk and facial expressions*' can help with infant brain development and how these techniques could be used by people who become parents in the future.

Subtheme 2: Promoting positive behaviours. Students linked the Oxford SEEN content to other topics covered in KS3 science, specifically the damage that smoking and alcohol can cause to a baby in utero. Students reflected that they wanted the Oxford SEEN lessons to cover more about the mechanisms by which the foetal brain is affected. Teachers also

highlighted how their students reflected on the importance of positive environments for infants, including the key role of caregiver–child interactions.

‘They were gobsmacked by putting a child down in front of a TV was not a suitably interactive experience’.

Teacher 8

Subtheme 3: Promoting gender equality. Teachers felt that the Oxford SEEN lesson content was important for challenging societal norms and that their students had discussed how any person can be involved in an infant's upbringing. They reflected that their students had learnt that there is *‘no gender bias about who should be looking after a child and speaking with it’*. A few schools brought in male staff from other departments who were caregivers into the lesson to talk about their role in a child's life.

Theme 2: An opportunity to share lived experience

Teachers reported that many of their students drew the Oxford SEEN lessons back to their own childhood and family lives. They felt this had given children a platform to talk about their own experiences. A small number of teachers reported that students had raised a concern about the relevance of the material covered to their own childhood experiences, including foster care, adoption, parental illness and bereavement. The teachers' reflections about the classroom discussions on these topics indicated that although questions were sometimes *‘difficult’* they felt able to manage their students' questions or concerns and had stressed the ongoing importance of neuroplasticity, particularly during adolescence.

‘I have a student ... whose mum died when she was 5 ... and I've never seen her write so much’.

Teacher 11

Teachers noted that these discussions prompted their students' *‘curiosity’* about their own brains and in particular neuroplasticity and the adolescent brain. One teacher felt that when their students were *‘lacking confidence... it gives them the opportunity to flip into that growth mindset’*. Teachers reported wanting more content to be devoted to neuroplasticity, and practical advice for the future. Students asked about the *‘next steps for me and my brain’*. Teachers linked the topics introduced into wider discussions about emotional intelligence and were able to match it to existing cross-curricular learning outcomes. Some teachers discussed wider concepts about perseverance and optimism.

‘The last lesson fed in beautifully with how we develop resilience and never giving up’.

Teacher 17

Theme 3: Relevance to the KS3 science curriculum

Many teachers argued that the Oxford SEEN content should be incorporated into the National Curriculum.

‘...would very strongly recommend it being introduced in the curriculum’.

Teacher 5

Most teachers reported that the Oxford SEEN lessons added a refreshing source of contemporary, flexible material that could guide further discussions, such as around epigenetics, future technologies or emotional intelligence. Several teachers also noted that teaching the sessions supported their continuing professional development (CPD) goals.

'We endlessly learn about the heart, but we learn very little about the brain'.

Teacher 3

Teachers' endorsement of the Oxford SEEN curriculum was reflected in several reporting that their school had decided to continue to teach it in following years and build it into their schemes of work.

DISCUSSION

The Oxford SEEN project used quantitative and qualitative methodologies to evaluate the effectiveness of three science lessons on increasing KS3 students' knowledge and practical understanding of the early years, including how to support children's brain development for lifelong health. Taking part in the Oxford SEEN lessons not only increased students' knowledge about the importance of the early years but was also associated with a positive shift in their understanding of how this knowledge could be applied to practical, day-to-day interactions with young children. These gains were maintained up to 2 months after completion of the lessons. These positive quantitative results were also reflected in the themes that emerged from the focus group discussions regarding teachers' and students' experience of the Oxford SEEN lessons.

Importantly, students reported sharing their new knowledge from the Oxford SEEN lessons with others outside of their class including parents, caregivers, other relatives and friends. Sharing knowledge is a key factor in active learning and information retention (Balta et al., 2017; Koh et al., 2018). Promoting sensitive interactions with young children is important in facilitating children's long-term cognitive, emotional and behavioural outcomes (National Scientific Council on the Developing Child, 2004). Delivering content about early child development to students at school could contribute to establishing a community-wide understanding about this critical period of development. This knowledge would facilitate political and societal action to recognise and address the impact of childhood adversity and improve future population health and well-being (Gold & Gottlieb, 2019). The evaluation of the Oxford SEEN project showed that it was feasible for secondary school science teachers in England to include three new science lessons about early brain development into the curriculum. Analyses showed the lesson content was appropriate and acceptable across a variety of educational settings with students of different ages, geographical location and disadvantage, which is important for building inclusive curricula (von Vacano et al., 2022). Importantly, all teachers who completed the feedback survey reported that they believed the content should be taught in schools. Teachers reported confidence in delivering the material, which is vital given the role of teacher self-efficacy in students' learning (Mojavezi & Poodineh Tamiz, 2012). The success of the SEEN lessons may reflect the comprehensive teaching pack which included all of the lesson materials and resources as well specific training for teachers; this minimised the time needed by staff to prepare for the lessons. The modest number of lessons may also have facilitated inclusion within the timetable.

Despite these favourable results regarding the feasibility and acceptability of the Oxford SEEN lessons for staff and students, it is important to recognise the reality of the overburdened KS3 science curriculum and provide a robust rationale for the inclusion of new

content. The SEEN content is consistent with the aims of the National Curriculum regarding the significance and use of science to society and student's lives and was created in collaboration with education leaders including a member from the Department for Education. Teaching students about neurodevelopment links into established areas of study, such as reproduction (Year 7), nervous system enrichment (Year 8) and introduction of coordination and control (Year 9). The data presented shows that it is possible to bring current scientific research into the classroom. The creation of materials in consultation with academic and education experts ensures the scientific integrity of the content and the suitability of the resources for the teaching community (Marshall et al., 2022). It makes an important contribution to the literature informing policy makers and educators on how to incorporate evidence-based theory into science curricula.

Strengths of the project

The evaluation of the Oxford SEEN project showed that the lesson content was appropriate and acceptable across a variety of educational settings with students of different ages, backgrounds and abilities and could be delivered by secondary school teachers in England. The impact of the lessons was not restricted to knowledge gain. Both students and teachers reflected on how the lessons would change their own interactions with young people (including younger siblings of students and children of teachers). With schools keen to engage students with a modern and relevant curriculum, the content offers an opportunity to learn the knowledge and skills that is relevant to them now and in the future. Students could see the relevance of the lessons to the science of learning, personal relationships, mental health, future roles as parents and career choices.

Limitations of the project

The delivery of the Oxford SEEN lessons may have varied between each school as no data were collected on how teachers taught every lesson in each school, although lesson guides and materials were extensive. Evaluation of students' knowledge used a 10 item MCQ developed by the authors for the purposes of this study; no suitable validated scale was available, which may limit interpretation of the results. There was limited data collected from the follow-up surveys (6–8-week post-lessons) due to this time point occurring during school holidays or absences due to the COVID-19 pandemic. The ability level of participating classes was not collected; consequently it was not possible to explore whether this affected students' scores. Longitudinal data such as students' subsequent A-level choices, higher education destinations or entry into careers relating to childcare were beyond the scope of the project.

Some teachers reported the amount of paperwork associated with the evaluation of the lessons was burdensome. There were no negative comments reported about the SEEN lessons themselves, with only minor suggestions regarding changes to the content. However, teacher feedback survey completion and focus group participation was not mandatory; it is therefore unclear about the extent to which the positive feedback reported was universal across staff who delivered the lessons. Data were not collected on teachers' years of experience or their level of engagement with the online training materials. Students completed surveys online or paper copies which may have hindered students who struggle with written tasks to communicate the full extent of their knowledge or practical skills.

Future questions

The Oxford SEEN lessons were developed for KS3 students; a stage when the science curriculum is universal. Future work could consider opportunities to develop the content for KS2 and KS4 students, or as parallel strands matching cross-curricular themes which could be covered in PSHE. Studies comparing different formats and lengths of delivery could be helpful to elucidate strategies to maximise impact and retention of the content for students of different abilities. Further research could utilise observational methods to analyse behaviour change in order to investigate whether and how students interact differently with babies and young children following the Oxford SEEN lessons.

This project has shown that it is possible to engage students and teaching staff with the importance of the early years and implement new curricula into existing school timetables. The mixed methods evaluation provides evidence that would recommend inclusion of the Oxford SEEN content into the national science curriculum. We propose that this new knowledge should be consolidated at later time points during education, professional training and perinatal education, with the aim of establishing a community-wide understanding of the importance of the early years for lifelong health.

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CONFLICT OF INTEREST STATEMENT

No known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

DATA AVAILABILITY STATEMENT

The anonymised data that support the findings of this study are available from the corresponding author upon reasonable request. Data used in this study may be accessed through a written request to the corresponding author. For access to the SEEN project lesson materials and resources visit Kindred2 (<https://kindredsquared.org.uk/seen-programme/>).

DISCLOSURE STATEMENT

The authors report that there are no competing interests to declare.

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REFERENCES

AFWI. <https://www.albertafamilywellness.org/> (n.d.)

Balta, N., Michinov, N., Balyimez, S., & Ayaz, M. F. (2017). A meta-analysis of the effect of peer instruction on learning gain: Identification of informational and cultural moderators. *International Journal of Educational Research*, 86, 66–77.

- Berens, A. E., Jensen, S. K. G., & Nelson, C. A. (2017). Biological embedding of childhood adversity: From physiological mechanisms to clinical implications. *BMC Medicine*, 15(1), 135. <https://doi.org/10.1186/s12916-017-0895-4>
- Bornstein, M. H., Arterberry, M. E., & Lamb, M. E. (2014). *Development in infancy: A contemporary introduction*. Psychology Press.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>
- Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, 18(3), 328–352. <https://doi.org/10.1080/14780887.2020.1769238>
- Department for Education. (2013a). HM government Great Britain. *Research Review Series: Science*. <https://www.gov.uk/government/collections/national-curriculum>
- Department for Education. (2013b). HM Government Great Britain. Science programmes of study: Key stage 3 National Curriculum in England. https://assets.publishing.service.gov.uk/media/5a7d563de5274a2af0ae2ffa/SECONDARY_national_curriculum_-_Science_220714.pdf
- Department for Education. (2021). HM government Great Britain. *Research Review Series: Science*. <https://www.gov.uk/government/publications/research-review-series-science/research-review-series-science>
- Department of Health and Social Care. (2021). HM government Great Britain. The best start for life: A vision for the 1,001 critical days: The early years healthy development review Report.
- Eshel, N., Daelmans, B., de Mello, M. C., & Martines, J. (2006). Responsive parenting: Interventions and outcomes. *Bulletin of the World Health Organization*, 84(12), 991–998. <https://doi.org/10.2471/blt.06.030163>
- Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., Koss, M. P., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The adverse childhood experiences (ACE) study. *American Journal of Preventive Medicine*, 14(4), 245–258. [https://doi.org/10.1016/s0749-3797\(98\)00017-8](https://doi.org/10.1016/s0749-3797(98)00017-8)
- Fonagy, P., & Target, M. (1997). Attachment and reflective function: Their role in self-organization. *Development and Psychopathology*, 9(4), 679–700. <https://doi.org/10.1017/s0954579497001399>
- Gold, R., & Gottlieb, L. (2019). National data on social risk screening underscore the need for implementation research. *JAMA Network Open*, 2(9), e1911513. <https://doi.org/10.1001/jamanetworkopen.2019.11513>
- Haley, D. W., & Stansbury, K. (2003). Infant stress and parent responsiveness: Regulation of physiology and behavior during still-face and Reunion. *Child Development*, 74(5), 1534–1546. <https://doi.org/10.1111/1467-8624.00621>
- Holman, J., & Yeomans, E. (2018). *Improving secondary science*. Education Endowment Foundation.
- Hughes, K., Bellis, M. A., Hardcastle, K. A., Sethi, D., Butchart, A., Mikton, C., Jones, L., & Dunne, M. P. (2017). The effect of multiple adverse childhood experiences on health: A systematic review and meta-analysis. *The Lancet Public Health*, 2(8), e356–e366. [https://doi.org/10.1016/s2468-2667\(17\)30118-4](https://doi.org/10.1016/s2468-2667(17)30118-4)
- Illingworth, G., Sharman, R., Harvey, C. J., Foster, R. G., & Espie, C. A. (2020). The Teensleep study: The effectiveness of a school-based sleep education programme at improving early adolescent sleep. *Sleep Medicine*, X, 2, 100011. <https://doi.org/10.1016/j.sleepx.2019.100011>
- Koh, A. W. L., Lee, S. C., & Lim, S. W. H. (2018). The learning benefits of teaching: A retrieval practice hypothesis. *Applied Cognitive Psychology*, 32(3), 401–410.
- Kurup, P. M., Levinson, R., & Li, X. (2021). Informed-decision regarding global warming and climate change among high school students in the United Kingdom. *Canadian Journal of Science, Mathematics, and Technology Education*, 21(1), 166–185. <https://doi.org/10.1007/s42330-020-00123-5>
- Kuyken, W., Ball, S., Crane, C., Ganguli, P., Jones, B., Montero-Marin, J., Nuthall, E., Raja, A., Taylor, L., Tudor, K., Viner, R. M., Allwood, M., Aukland, L., Dunning, D., Casey, T., Dalrymple, N., De Wilde, K., Farley, E. R., Harper, J., ... Williams, J. M. G. (2022). Effectiveness and cost-effectiveness of universal school-based mindfulness training compared with normal school provision in reducing risk of mental health problems and promoting well-being in adolescence: The MYRIAD cluster randomised controlled trial. *Evidence-Based Mental Health*, 25(3), 99–109. <https://doi.org/10.1136/ebmental-2021-300396>
- Magaji, A., Ade-Ojo, G., & Bettene, M. (2018). Towards a pedagogy of science teaching: An exploration of the impact of students-led questioning and feedback on the attainment of key stage 3 science students in a UK school. *International Journal of Science Education*, 40(9), 1076–1093. <https://doi.org/10.1080/09500693.2018.1473658>
- Marshall, M., Davies, H., Ward, V., Waring, J., Fulop, N. J., Mear, L., O'Brien, B., Parnell, R., Kirk, K., Reid, B., & Tooman, T. (2022). Optimising the impact of health services research on the organisation and delivery of health services: A mixed-methods study. *Health and Social Care Delivery Research*, 10, 3. <https://doi.org/10.3310/HF003193>
- Meins, E., Fernyhough, C., Fradley, E., & Tuckey, M. (2001). Rethinking maternal sensitivity: Mothers' comments on infants' mental processes predict security of attachment at 12 months. *Journal of Child Psychology and Psychiatry*, 42(5), 637–648. <https://www.ncbi.nlm.nih.gov/pubmed/11464968>

- Mills-Koonce, W. R., Willoughby, M. T., Zvara, B., Barnett, M., Gustafsson, H., Cox, M. J., & Family Life Project Key, I. (2015). Mothers' and Fathers' sensitivity and Children's cognitive development in low-income, rural families. *Journal of Applied Developmental Psychology*, 38, 1–10. <https://doi.org/10.1016/j.appdev.2015.01.001>
- Mojavezi, A., & Poodineh Tamiz, M. (2012). The impact of teacher self-efficacy on the Students' motivation and achievement. *Theory and Practice in Language Studies*, 2(3), 483–491.
- National Scientific Council on the Developing Child. (2004). Young children develop in an environment of relationships.
- Potvin, P., Nenciovici, L., Malenfant-Robichaud, G., Thibault, F., Sy, O., Mahhou, M. A., Bernard, A., Allaire-Duquette, G., Sarrasin, J. B., Foisy, L. M. B., Brouillette, N., St-Aubin, A. A., Charland, P., Masson, S., Riopel, M., Tsai, C. C., Bélanger, M., & Chastenay, P. (2020). Models of conceptual change in science learning: Establishing an exhaustive inventory based on support given by articles published in major journals. *Studies in Science Education*, 56(2), 157–211. <https://doi.org/10.1080/03057267.2020.1744796>
- Shonkoff, J. P., & Bales, S. N. (2011). Science does not speak for itself: Translating child development research for the public and its policymakers. *Child Development*, 82(1), 17–32. <https://doi.org/10.1111/j.1467-8624.2010.01538.x>
- Shonkoff, J. P., Garner, A. S., & The Committee on Psychosocial Aspects of Child and Family Health, Committee on Early Childhood, Adoption, and Dependent Care, and Section on Developmental and Behavioral Pediatrics. (2012). The lifelong effects of early childhood adversity and toxic stress. *Pediatrics*, 129(1), e232–e246. <https://doi.org/10.1542/peds.2011-2663>
- von Vacano, C., Ruiz, M., Starowicz, R., Olojo, S., Moreno Luna, A. Y., Muzzall, E., Mendoza-Denton, R., & Harding, D. J. (2022). Critical faculty and peer instructor development: Core components for building inclusive STEM programs in higher education. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.754233>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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