Institution: Oxford Brookes University

Unit of Assessment: 23, Education

Title of case study: Creative Primary Science Pedagogies: transforming approaches to teaching and learning

Period when the underpinning research was undertaken: 2001–2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Deb McGregor	Professor in Learning and Developing Pedagogy	[text removed for publication]
Helen Wilson	Principal Lecturer in Early Years and Primary Science Education	

Period when the claimed impact occurred: 2014–2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

The research of Professor Deb McGregor and Helen Wilson has, since 2014, focused on investigating effective creative pedagogies, particularly through the *Thinking, Doing, Talking Science* (TDTS) project. This research has had lasting impact in the following ways:

- Pupil outcomes: Educational Endowment Fund (EEF) data shows that TDTS pedagogies extend pupil attainment by up to five months.
- Teaching Practice and Professional Development: teachers report using TDTS strategies years after involvement in training.
- Science pedagogy: TDTS has directly informed the approaches to science pedagogy adopted by leading national and international institutions, including the Wellcome Trust and Science Oxford.

2. Underpinning research

The research collaboration between McGregor and Wilson commenced in 2012 and it invigorated the development and conceptualisation of the TDTS project and Science Technology Engineering Arts and Mathematics (STEAM) research at Oxford Brookes University. Their research interest in science learning promoted the generation of innovative pedagogies that extend beyond the transmission mode of teaching routinely adopted to prepare 11-year-olds for Statutory Assessment Tasks (SATS).

The initial work commenced in 2002 when the AstraZeneca Science Teaching Trust, now the Primary Science Teaching Trust (PSTT), funded a two-year project, entitled 'Conceptual Challenge in Primary Science' (GBP140,000) led by Wilson to explore how to equip primary teachers to engage children in thinking more deeply about science **[Grant A]**. Adopting a matched pair comparison, the study examined the impact of a creative approach to primary science in 32 English primary schools. Comparing classes of 10-11-year-old children demonstrated an emphasis on deepening *thinking* (to resolve conceptually challenging conundrums), *doing* (practical problem-solving activities) and *talking* (to engage dialogically with scientific ideas) increased pupils' enthusiasm and attainment in the subject. Thinking and working scientifically in school classrooms involves more than learning scientific facts. Wilson's early work **[R1]** showed how 11-year-olds could improve their academic attainment whilst engaging in thought-provoking, open-ended science tasks.

The research synergy between McGregor and Wilson's work enables them to advance and deepen the suite of TDTS pedagogic approaches, including 'Bright Ideas Time' and different teaching strategies, such as Big Questions, Odd One Out and Positive Minus Interesting. These strategies

are linked to National Curriculum levels and objectives and are designed as 'discussion prompts', enabling practitioners to inclusively and actively engage learners in *thinking*, *doing* and *talking* science. For example, the Odd One Out involves asking, 'Which is the odd one out and why?', using a prompt (a teddy bear, a dog and a tree). Often young children do not think that a plant is alive, so this may spark interesting debate **[R1]**. These approaches were theorised to clarify how and why TDTS works to encourage critical questioning, which in turn can help improve academic performance as well as enjoyment of science **[R2, R3]**.

Collaboration between Wilson and McGregor has led to dissemination of various elements of the TDTS approach nationally and internationally, leading to further impact on teacher training and science pedagogy. TDTS has been adapted by McGregor to dramatize learning, which has been taken up by colleagues, for example, in New Zealand and Sweden **[R4]**. They recognise, have adopted and written about the participatory constructivist TDTS approach, which promotes a combination of talking and doing to deepen and enhance thinking.

McGregor's research has further revealed the ways various TDTS interventions promote cognitive development through engaging learners strategically in different ways of thinking about challenging problems by the use of drama **[Grant B]**. Facilitating discussion through thinking frameworks has shown the impact of pedagogical approaches that: i. frame open-ended learning activities; ii. present different forms of cognitive challenges to learners; iii. mediate group participation to solve scientific conundrums **[R5]**; iv. encourage evidenced responses to tasks; and v. celebrate all relevant forms of creative thinking **[R3, R4, R6]**.

3. References to the research

R1. Mant, J., Wilson, H. & Coates, D. (2007). The Effect of Increasing Conceptual Challenge in Primary Science Lessons on Pupils' Achievement and Engagement. *International Journal of Science Education, 29*(14), 1707-1719. DOI: 10.1080/09500690701537973

R2. McGregor, D., Wilson, H., Bird, J. & Frodsham, S. (2017). Creativity in Primary Science: Illustrations from the classroom. Bristol: Primary Science Teaching Trust (available here).

R3. McGregor, D., Frodsham, S. and Wilson, H. (2020). The nature of epistemological opportunities for doing, thinking and talking about science: Reflections on an effective intervention promoting creativity. *Research in Science and Technology Education.* DOI: 10.1080/02635143.2020.1799778

R4. McGregor, D., Baskerville, D., Anderson, D., Duggan, A. (2019). Examining the use of drama to develop epistemological understanding about the Nature of Science: A collective case from experience in New Zealand and England, UK. *International Journal of Science Education, 9*(2), 171-194. DOI: 10.1080/21548455.2019.1585994

R5. McGregor, D., & Frodsham, S. (2019). Epistemic insights: Contemplating tensions between policy influences and creativity in school science. *British Educational Research Journal, 45*(4), 770-790. DOI: 10.1002/berj.3525

R6. Frodsham, S., McGregor, D. & Wilson, H. (2014). Young children's views of creativity in Science: Exploring perspectives in an English Primary Classroom. *The Journal of Emergent Science 8*, 31-41. (available here)

Grant A. Conceptual Challenge in Primary Science, PI Wilson, AstraZeneca Science Teaching Trust (AZSTT), 2002–2004, GBP140,000

Grant B. Exploring and Exemplifying Creativity, PI McGregor, Primary Science Teaching Trust (PSTT), 2017–2020, GBP150,000, plus additional funding GBP21,277.50

Grant C. Science Education Hub (involving continuing research in primary pedagogy and learning), PI McGregor, PSTT, 2013–2016, GBP148,800

Evidence of quality: External national agencies committing significant funds to establish the efficiency and effectiveness of TDTS approach – including Education Endowment Foundation (awarded to the Oxford Trust/Science Oxford, co-led by Helen Wilson) and Primary Science Teaching Trust.

4. Details of the impact

Impact on pupil outcomes

The Education Endowment Foundation (EEF) funded a first efficiency trial of TDTS (2013–2015), designed as a randomised controlled trial (RCT), with 42 participating schools and 1,200 Year 5 pupils (aged nine to ten) involved. The RCT indicated that there was a statistically significant impact on pupils' attainment, with a gain in their learning that was equivalent to three months of additional progress, as a result of their classroom teachers adopting the TDTS strategies. In addition, the trial suggested that that the TDTS programme had a positive effect on girls and on pupils with low prior attainment **[S1.1]**. To date, at least 8,500 pupils have been involved in the EEF-funded trials focusing on TDTS **[S1.1, S1.2, S1.3]**. The EEF recognise the significant potential of this teaching approach and have committed a further effectiveness trial (costing GBP839,256) involving 180 schools and over 10,000 pupils **[S1.4]**. This second effectiveness retrial, involving a 'train-the-trainer' approach to disseminate even more widely the TDTS resources and pedagogic strategies, began in September 2020. This significant work will also assess the extent to which training trainers could effectively 'roll-out' nationally the TDTS to all primary schools. The EEF have invested GBP1,889,301 so far to establish efficiency and effectiveness of TDTS to make science lessons more effective **[S1.4]**.

Impact on teaching practice and professional development

The impact of the TDTS teaching interventions on teaching practice is evidenced by the sustained adoption of TDTS strategies (Odd One Out, Big Questions, Positive Minus Interesting) by teachers in the UK. A recent survey confirmed that, several years after being trained in using TDTS, all teachers (n=16) responding to the legacy questions still encourage pupils to question; 93% still utilise Odd One Out; 87% still ask Big Questions; 80% say they still create space for pupils to think. One teacher, still using these strategies after 18 years, said they are 'all proven to be effective ways to encourage children to think scientifically'. Others surveyed describe TDTS as 'fun and engaging'; that it 'gets the children doing practical stuff and thinking and talking more'; that it 'gives voice to their ideas'; and also 'puts the children in control in a creative way'. As one teacher stated, it is 'absolutely amazing! It's hands-on exploration and discovery' **[S3.3]**.

The research **[R1]** has also informed the design of effective professional development activities focusing on teaching practice. It has led to the creation of engaging and challenging learning activities captured in handbook guidance to assist teaching the TDTS approach **[S2.5]**. The guidance was taken up by 84 teachers in 42 schools (in the 2013–2015 EEF RCT project), and later by 400 teachers in 200 schools (in the 2016–2018 EEF RCT project) **[S1.4]**.

The national and international reach of this intervention is noted by the CEO of the Primary Science Teaching Trust (PSTT): "*We have invested further in supporting dissemination of the TDTS approach by part-financing an administrative post, organising training of regional mentors, CPD events and providing on-line spaces for a range of the teaching approaches (Bright Ideas, Dramatic Science, Creative practice etc) Wilson and McGregor have developed. In augmenting the dissemination of Wilson and McGregor's projects, and investing in a variety of approaches to CPD, we have sought to ensure the work of these two innovative and creative academics has impacted nationally and internationally on the practice of primary science teachers and improved the science learning experience and attainment of many more 1,000s of primary aged children*" **[S2.1]**. This is further evidence by the PSTT's investment in various projects delivered by Oxford Brookes University, as well the Trust's website, used to disseminate the use of TDTS in schools across England and Wales, Scotland, and Northern Ireland **[Grants B and C]**.

The adaptation of TDTS approach has been corroborated by Suffolk County Council **[S2.2]**, South Essex Teaching School Alliance (SETSA) **[S2.3]** and Stoke-on-Trent councils, each funding cohorts of 40 teachers to be trained (which subsequently impact on at least 30 pupils per teacher). For example in Suffolk (2016-17) the EEF and Suffolk County Council together created a 'Raising the Bar Challenge Fund'. Suffolk primary schools could choose one of the successful EEF-funded initiatives for implementation in their school, and 20 Suffolk primary schools made TDTS their chosen initiative, with 40 teachers participating. These teachers recognized how TDTS was 'motivating, hands-on, challenging' but, most importantly, pupil centered. Furthermore, the science lead at St Thomas More's Catholic Primary School, Colchester said: "*Before TDTS a lot of our*

science involved a demo at the front of the class and a worksheet to follow up. We now have everyone involved in science and there is a real buzz of excitement when the children know there is a science lesson coming. Teachers, too, have gained in confidence" **[S2.3]**.

The TDTS strategies have also been applied in secondary schools across Herefordshire via the Strategic School Improvement Fund to improve their science provision at Key Stage 3 (Year 7). Teachers indicate how the strategies are 'stimulating, practical and fun' and 'the follow up work conducted after the sequence of CPD revealed a number of schools which had undertaken a major re-write of their schemes of learning that they taught'. STEM Education Lead for the Gloucestershire, North Wiltshire and Swindon Science Learning Partnership noted: "*The continuing professional development model (CPD model) used involved the collaborative development of lesson ideas and resources to support the development of teachers identified as being directly involved in the project and the school science departments from which they originated. The follow up work conducted after the sequence of CPD revealed a number of schools which had undertaken a major re-write of their schemes of learning that they taught*" **[S2.4]**. Further impact on teacher development can be seen in the work of the organisations mentioned below.

Impact on science pedagogy

TDTS has directly informed approaches to science pedagogy adopted by leading national and international organisations beyond academia. The design and creation of the state-of-the-art Science Oxford Centre, the first indoor-outdoor primary science focussed centre in the UK **[S3.1, S3.2]**, costing GBP13,000,000 (funded by the Royal Commission for the Exhibition of 1851) and opened in 2019, includes spaces and hands-on exhibits that directly adopt the TDTS constructivist approach. These exhibits, i. present conundrums to learners; ii. promote group engagement; iii. encourage creative and higher order thinking; and iv. provide participatory learning tasks that make a difference in engaging learners in *thinking*, *doing* and *talking* about science. The Director of Education and Engagement at Science Oxford, leads professional development programmes for teachers. She indicates how developing higher order thinking that echoes the TDTS ethos has profoundly influenced her work at Science Oxford. The effects on her TDTS-informed approach to teaching led to her being awarded the 2020 Beetlestone Award, a marker of national esteem in UK STEM education "*with particular recognition for my work on TDTS with Helen Wilson and my creation of the new Science Oxford Centre"* **[S3.1]**. Oxford Brookes University researchers and teacher training lecturers continue to collaborate closely with Science Oxford **[S3.3]**.

Key 'Bright Ideas Time' strategies (Odd One Out, What if, Big Questions) have also been adopted and adapted by the Wellcome Trust to develop *Explorify* (https://explorify.wellcome.ac.uk/), a free digital product to help teachers deliver great primary science teaching that meets both pupils' and teachers' needs **[S4.2]**. Programme Manager (Education) noted that Wellcome worked with a range of partners to solve the problem of how to reach teachers and support them to teach better science: "*Workshops to explore potential ways forward highlighted that the strategies developed in Thinking Doing Talking Science (TDTS) could be powerful. TDTS had just completed a trial that indicated significant impacts in developing pupils' higher order thinking skills. At the end of the workshops we had a list of 19 possible activities, including three from TDTS that were put forward for a proof of concept trial with teachers in June 2016*" **[S4.1]**. Eight activities were developed from the original list for *Explorify*, including all three activities from TDTS. For example, Odd One Out 'The drinks menu' is showcased as one of three exemplar activities on the main home page and it is noted that this activity is great for promoting observation and discussion skills.

Explorify is available to teachers around the world through an online platform (accessed so far by 18,956 schools; around 50% of UK primary schools have at least one teacher using it). It is promoted by the Association of Science Education (ASE) nationally and internationally and is also adopted for teacher training, including the Oxford Brookes University teacher education programmes **[S3.3]**. *Explorify* has been so successful that it has now extended the adaptation of TDTS strategies to offer age-related materials beyond that initially intended from the Bright Ideas suite for nine and ten-year olds. There are now activities emerging from TDTS for pupils 5-7, 7-9 and 9–11 years of age. The 'Bright Ideas Time' strategies are also promoted as evidence of best practice for science pedagogy through the PSTT website **[S3.4]**, through which TDTS has reached at least 13,012 teachers **[S2.1]**.

Since collaborating with Wilson, McGregor has been invited by The Comino Foundation to inform the 2020–2030 Arts Council 'Let's Create' agenda. McGregor contributed to this consultation and report by sharing how the TDTS approach has impacted in a combinatorial way on children's scientific creativity and attainment **[S3.5]**. Understanding how to pedagogically promote creativity in learning has also resulted in invitations for McGregor to deliver keynotes and contribute as an expert witness to, for example, the National Curriculum Science Group (May 2020). Her input has been to inform the pedagogic approach to promoting creativity through 'thinking, doing and talking about science' for the future primary National Curriculum **[S3.6]**. McGregor has also regularly written for the ASE (https://www.ase.org.uk/) in their books and other resources for teachers.

As a result of involvement in the largest EEF-funded educational RCT to date, Wilson is now advising on the design of medical interventions, through Informed Health Choices (IHC). As a member of the International Advisory Group for the IHC projects funded by the Research Council of Norway (2013–present), the TDTS evaluation framework has been adopted to assess the claims about treatments and educational resources for primary school children and their parents in Uganda, Kenya, Rwanda and Norway **[S4.3]**.

5. Sources to corroborate the impact

S1. External national agencies funding projects evidencing impact on pupil attainment

S1.1 Institute for Effective Education: Hanley, P., Slavin, R. and Elliott, L. (2015) *Thinking, Doing, Talking Science: Evaluation report and Executive summary.* Research Report. Education Endowment Foundation, London. (here)

S1.2 American Institute for Research: Kitmitto, S., González, R., Mezzanote, J. and Chen, Y. (2018). *Thinking, Doing, Talking Science. Evaluation report and Executive Summary*. Education Endowment Foundation, London. (here)

S1.3 Slavin, R., Lake, C., Hanley, P. and Thurston, A. (2012) Effective Programs for Elementary Science: A Best-Evidence Synthesis, Best Evidence Encyclopaedia (here)

S1.4 Educational Endowment Fund: (i) Efficacy trial of Thinking, Doing, Talking Science, GBP270,000 (information here); (ii) First effectiveness trial, GBP780,045 (information here) and (iii) Second re-grant of effectiveness trial, GBP839,256 (information here)

S2. External agencies recognising impact on professional development nationally

S2.1 Testimony from CEO of the Primary Science Teaching Trust

S2.2 Testimony from Suffolk County Council

S2.3 Testimony from South Essex Teaching School Alliance

S2.4 Testimony from Herefordshire pilot

S2.5 Wilson, H. and Mant, J. *Creativity and Excitement in Science: CPD handbook*. Lessons from the AstraZeneca Science Teaching Trust Project 2002–2004 (here)

S3. External agency adopting TDTS philosophy

S3.1 Testimony from Director of Education and Engagement at Science Oxford

S3.2 Science Oxford website promoting TDTS (here)

S3.3 Reflections on the impact of TDTS: Teacher's perspectives (here)

S3.4 Primary Science Teaching Trust website: Bright Ideas Time (here)

S3.5 The Comino Foundation: Teaching for Creativity Report March 2020 (here)

S3.6 Testimony from Primary Science Curriculum Group

S4. International organisations employing the use of aspects of TDTS about science to promote creativity

S4.1 Testimony from Primary Science Programme Lead, The Wellcome Trust

S4.2 Wellcome Trust teaching resource, *Explorify* (here)

S4.3 Testimony from Informed Health Choices, Norway