A socio-constructivist approach to developing a professional learning intervention for early childhood education and care practitioners in Wales

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Abstract

In 16 Flying Start early childhood education and care (ECEC) settings within a Local Authority in Wales, observations of adult-child interactions, using the Sustained Shared Thinking and Emotional Wellbeing Scale (SSTEW), highlighted that interactions that support children's problem solving, curiosity, concept development, and higher-order thinking were the least well developed aspects of practice. A two-day professional learning intervention 'Talking Science', underpinned by a socio-cultural understanding of science learning in ECEC was designed. The intervention was delivered via a collaborative, socio constructive model of delivery en masse to all 64 practitioners in the 16 Flying Start settings. This qualitative mixed method research project adopted an interpretivist paradigm; the aim was to better understand ECEC practitioners' perceptions of science and how these perceptions both shaped provision and supported children's concept development in their settings. Data collection took the form of scribed notes from group discussions, feedback from practitioners during discussions and evaluation feedback about 'Talking Science'. The experiential professional learning programme with a focus on science in everyday practice appeared to be supportive of practitioners' developing confidence and subsequent engagement with science provision for young children. 'Talking Science' also provides a model which may have wider implications when designing ECEC professional learning.

Key Words: ECEC, science, sustained shared thinking, problem solving, professional learning, perceptions of science

Introduction

Background and Context

Studies into effective early childhood education and care (ECEC) emphasise the importance of the role of the adult and the quality of adult-child interactions on a child's long term development, learning and achievement (Siraj- Blatchford *et al.* 2002, Sylva *et al.* 2004, Siraj-Blatchford *et al.* 2008, Sammons *et al.* 2014, Melhuish 2016, Melhuish *et al.* 2017) and thus the 'Talking Science' professional intervention outlined in this article was designed to support these aspects of ECEC practice. The model for delivering 'Talking Science' considered the wider complexities noted by Waters and Payler (2015), Philippou *et al.* (2015) and Nuttall *et al.* (2015), in terms of the context of the ECEC professional learning landscape.

International literature uses many terms when referring to adults working with young children, reflecting the different contexts and school starting ages in different countries; thus for the purposes of this article and in line with Waters and Payler (2015), the term ECEC practitioners is used to represent the professional practitioners such as teachers and pre-school early years professionals working with children from 0-8 years old.

Background and approach to professional learning

Waters and Payler (2015) discuss the priorities in ECEC of having professional learning which is systematic, transformative and sustainable. They also note that ECEC has distinctive needs from other education sectors and is only recently developing robust and diverse approaches to professional learning. The specific needs in Wales in terms of ECEC highlight these complexities where practioners may have vocational qualifications, have academic graduate qualifications, apprenticeships or no formal ECEC qualifications, depending on the ECEC specific sector they work in. Furthermore the delivery of ECEC may have significant challenges in terms of providing high quality professional learning in a complex sector which includes Government maintained, private and voluntary ECEC providers, reflecting the international context noted by Waters and Payler (2015). As a result, ECEC professional learning takes place in a system where funding, regulatory systems and provider types can make developing systematic, transformative and sustainable professional learning difficult. These challenges and the underpinning context of children's rights (Welton *et al.* 2019) and increasing levels of childhood poverty in Wales (WG 2014) were a significant consideration when developing 'Talking Science'. The programme was therefore designed to reflect the policy context in terms of cost effectiveness and productivity (Balls, 2013 cited in Waters and Payler 2015) while improving outcomes for children (Trodd and Dickerson 2019). However the specific context of the ECEC practitioner was also a key consideration when designing 'Talking Science'. Trodd and Dickerson (2019, p.370) suggest that professional learners are 'learners who value and share learning and demonstrate enthusiasm for learning in settings where they are uniquely placed to influence children at an early age of their learners journey'. However, in a sector with a diverse range of practitioners and complex professional identities (Lightfoot and Frost, 2015), creating valuable professional learning can be difficult when the context and values of the practitioners themselves are not given a voice. The model outlined below for delivering 'Talking Science' was designed to consider participants own socio-cultural context and perceptions in relation to ECEC and science. This was to provide a platform for discourse as a means to support the participants' own confidence to make science visible in their ECEC practice. Furthermore, the model included a cross-disciplinary approach where the authors who designed and supported the professional development were a team who had science as well as ECEC expertise. Kirkby *et al.* (2019) considered the significant benefits of an interdisciplinary approach to ECEC professional learning and the opportunities to create a community of practice sharing expertise and Lightfoot and Frost (2015) and Hadley *et al.* (2015) suggested that external expertise can support transformative change.

Kirby *et al.* (2019, p.264) suggest that 'the development of practices, repertoires and professional identities' can be supported 'by a range of approaches' and when designing and planning 'Talking Science' a key emphasis was the need for systematic, transformative and sustainable change (Waters and Macdonald under review) as outlined in the literature review below.

Literature Review

Systematic

'Talking Science' was provided *en masse* for all settings' staff. Flying Start have closure sessions to provide whole staff development and this allowed the entire staff of each setting to attend the professional learning programme together. Managers, advisory leads and less experienced staff were part of the same experience. Waters and Macdonald (under review) suggest this provided a systematic approach, with the potential to impact across an entire setting or a group of settings. This also avoided the cascade model of development which is often utilised when one or two members of staff are part of a professional learning programme and are then tasked with sharing the information with other practioners within the setting. Although cost effective and less disruptive in terms of staff being absent from their work duties, the cascade model has been critiqued in terms of a dilution of information as you move down the cascade (Hayes 2000). In 'Talking Science' an *en masse* model provided the opportunity for key ideas and discussion to be visible to all members of each setting.

Transformative

Waters and Macdonald. (under review) frames transformative as professional learning that impacts upon the pedagogical and praxaeological work of the individual, developing their professional practice and therefore the experiences of the children with whom they work. 'Talking Science' was not a 'one-off-training day' model which Hadley *et al.* (2015) noted may not support transformative change in practice. Instead it involved two days of workshops with time built in to allow participants to use approaches from day 1 in their settings and to reflect on these on day 2. Furthermore, Lightfoot and Frost (2015) consider that transformative professional learning requires a setting based group, is supported by external expertise, and allows for peer and senior leadership support within a wider network of like-minded individuals. Therefore ‘Talking Science’ involved all ECEC setting staff including the senior leadership. There was also collaboration across all 16 settings making up the Flying Start settings in the Local Authority, so that a network of different settings could share knowledge. As noted by Moyles and Adams (2000, p.1) ‘changes in practice are likely to remain at the procedural level without significant time and effort spent on developing a secure philosophical and ideological basis for practitioners’ and thus ‘Talking Science’ was designed as a forum for participants to share their perceptions and context in terms of science. Furthermore, there was an opportunity to actively deconstruct knowledge through reflection (Philippou *et al.* 2015). McMillan *et al.* (2012) highlight the significance of a sociocultural theoretical framework and thus ‘Talking Science’ was based on including opportunities to consider the participants own social contexts and experiences and how these support their engagement with their practice. Molla and Nolan (2019) suggested the need for deliberation in professional learning where there is an opportunity for ECEC practioners to be able to actively and carefully consider their own knowledge and beliefs in a supportive learning community. Therefore the ‘voice’ of the participants was and integral part of the professional learning, where the reflection on their personal experience was a recognition of their specific starting points, which Lightfoot and Frost (2015) consider significant to developing transformative change.

Children’s interest in science appears to decrease from the age of 10 years and through secondary education (Osborne *et al.* 2003, Hutchinson *et al.* 2009). Experiences of school science can also affect interest in science, with negative experiences decreasing students’ interest in science; and positive experiences leading to enjoyment and interest (Cleaves 2005, Lyons 2006, Stake 2006, Aschbacher *et al.* 2010). DeWitt *et al.* (2011), from research with year six pupils (10-11 years of age), suggested that at this age there was a group of students 'for whom science may be an unthinkable identity' (p.1052). It is possible that this science negativity is reflected in the ECEC sector. For example, Yoon and Onchwari (2006) noted that ECEC practitioners avoided teaching science as they viewed it as difficult; and too hard for young children (Metz 2009, Brenneman 2010). However more recent research by Pendergast *et al.* (2017), in a single US state, found positive attitudes and beliefs from prekindergarten practitioners who did not demonstrate fear of science and their ability to teach it, neither were they concerned about answering questions from children. 'Talking Science' in line with McMillan *et al.*'s (2012) socio-cultural approach to ECEC professional learning, included a forum which was designed to encourage discourse as well as provide opportunities to actively reflect on recent ECEC science concept development practice.

ECEC professional learning models have also considered the significance of reframing specific curriculum areas that ECEC practioners may require support, so that the context is linked to play and the everyday pedagogy of ECEC practice. Perry and MacDonald's (2015) research highlighted how ECEC practioners in an Australian context were reluctant to provide mathematical experiences and that the Let's Count professional learning programme reframed mathematics within the context of 'play' which developed more positive collaborations between parents, children and ECEC practitioners.. Nuttall *et al.* (2015) also discussed the benefits of reframing professional learning relating to ECEC digital technology, by taking a play-based perspective. In their study they suggested the professional learning was meaningful, as it is encapsulated the embodied experiences of ECEC practitioners. Similarly, Philippou *et al.* (2015) supported an inquiry based approach to professional learning for science and mathematics in ECEC- re-contextualising the experience as practical, and not distant from the reality of practice. Here Philippou *et al*. (2015) did not focus on science and mathematics knowledge and understanding in isolation, and instead considered a constructivist approach where participants were encouraged to think like scientists, in terms of posing questions and problems, and developing inquiry based learning.

Therefore the 'Talking Science' professional learning programme actively engaged participants in play based activities. A socio-constructivist approach was adopted where learning was viewed as cultural enactment (Vygotsky 1978, Daniels *et al.* 2010). Therefore learning about science was interactional in terms of participants/expert, and participants/participants, leading to the co-construction of an accessible pedagogy of science. This was therefore a collective activity as participants interacted with each other whilst engaging experientially in activities such as water play, small world play or nature play and discourse was a fundamental part of this engagement. The professional learning also encouraged participants not to 'fear being wrong', reflecting Brunton and Thornton's (2010, p. 12) notion that: 'As children are not encumbered with 'knowing the right answer' they can prove to be the initiators of wonderful ideas, which in turn can be far more interesting to explore than anything most adults would think of.' Furthermore, ECEC research advocates introducing science to young children early (Duschl *et al.* 2007, Metz 2009); and that when developmentally appropriate science experiences are offered to young children they foster a lifelong positive attitude to science (Metz 2009, Edwards and Loveridge 2011). However Tu, (2006) and Tu and Hsiao (2008) found that science did not feature highly in preschool practitioners' subject preferences and thus they rarely engaged in science instruction. Similarly, Andersson and Gullberg (2014) reported that action research with pre-school practitioners in Sweden highlighted: their negative feelings linked to science; their concerns about posing or responding to children's questions; their lack of subject knowledge; and difficulties planning activities for young children. To counter this Andersson and Gullberg (2014) suggested that science in preschool should be a way of empowering children where preschool practitioners develop skills which include: using the child's previous experiences; capturing unexpected things when they occur; asking questions that challenge and stimulate children's further investigation; and listening to children's ideas and explanations. To achieve this they suggested an approach focusing on encouraging children's engagement and enjoyment rather than subject matter alone, which also supports creative learning and child-led pedagogies in this context (Brunton and Thornton 2010, Cremin *et al.* 2015). 'Talking Science' modelled the same focus on child-led, fun and everyday play based activities already familiar to ECEC, as opposed to 'special science activities'.

Wright and Gotwals (2017) found that young children in mid-west American kindergartens, when receiving support and appropriate scaffolding, participated in sophisticated science talk. They suggested that as children start to engage in science, and thus the science community, they need scaffolding from more knowledgeable and experienced members of that community. Ash (2004) also noted that informal science talk also often developed to broader scientific literacy. 'Talking Science' thus focused significantly on science talk, adopting a similar approach with the participants to that used when engaging with young children; including hands on inquiry, the use of open ended questions, talk, modelling and ensuring that 'mistakes' were always viewed as a positive learning opportunity. 'Talking Science' provided practical, fun activities allowing small groups to explore everyday activities that might occur in ECEC settings, with the objective of encouraging discussion, experimentation and 'science talk' such as 'what happens if', or 'why did that happen'. This approach was informed by Katz's (1993) work on dispositions for learning, developing practice where practitioners and children want to explore, discover and develop ideas together. It also supported the sustained shared thinking context (Siraj-Blatchford *et al.* 2015), which underpins the initial SSTEW rating scale observation in the Flying Start settings (see later section).

Research has suggested that girls' and boys' confidence in mathematics and science vary with girls being less confident and having a more negative attitude (Correll, 2001, National Council for Research on Women 2001). This is particularly pertinent for the ECEC workforce since it is predominantly female. The Department for Education (DfE) (2011) suggested that for full-time paid workers in full day care, in the ECEC workforce in England, only 2% were male practitioners. The gender context is similar in Wales. All participants in 'Talking Science' were female. It is thus a concern that, if as children themselves, female ECEC practitioners had less positive attitudes and/or experiences, that this continues into adulthood and thus into their working practices with young children.

Sustainable

Waters and Macdonald. (under review) suggest that sustainable professional learning has a longitudinal impact for the individual, setting or group of settings. 'Talking Science' was devised and implemented through a collaboration between two Flying Start advisory leads, 16 Flying Start settings in one Local Authority and higher education staff with a science and ECEC expertise. From the onset when using the initial STTEW observations to measure setting quality in order to target areas for professional learning, the Flying Start advisory leads and their settings were an integral part of the work, and were also part of the 'Talking Science' intervention, allowing a collaborative approach to design specific and relevant professional learning. This is line with Hadley *et al.* (2015, p.190) who suggest that professional learning should be 'relevant, properly costed and evaluated against individual staff development plans and organisational goals'. The use of the SSTEW scale, and the subsequent collaboration between the Flying Start practitioners, advisory leads and higher education staff to target specific areas for professional learning as well as the *en masse* model adopted appeared to be sustainable, at least in relation to the second SSTEW observations up to 6 months–1 year after the 'Talking Science' intervention Waters and Macdonald (under review). The authors would argue that this was also linked to the specific social-cultural / socio-constructivist approach of the ‘Talking Science’ intervention, highlighted within this article.

Context for the SSTEW quality rating observational tool

Several authors note the crucial role ECEC practioners play in supporting children’s development and outcomes (Walters and Payler 2015, Howard *et al.* 2018, Kirby *et al.* 2019, Trodd and Dickerson 2019) and the importance, of high quality interactions that support and extend children’s thinking (Howard *et al.* 2018). The Researching Effective Pedagogy in the Early Years (REPEY) study (Siraj-Blatchford *et al.* 2002) demonstrated that high quality provision in ECEC settings had long-term effects on children’s outcomes. Effective pedagogy was underpinned by ECEC practioners’ skills and abilities to develop high quality adult interactions with children. Co-construction of knowledge between children and adults; development of sustained shared thinking; and the promotion of problem solving were some of the key aspects correlated with positive adult-child interactions (Siraj-Blatchford *et al.* 2002) and are also pertinent when developing young children’s engagement with science concepts (Brunton and Thornton 2010). ‘Sustained Shared Thinking’ in ECEC is considered to be the co-construction of knowledge and a period of sustained engagement through interaction with peers and adults, stimulating a deep level of learning (Siraj-Blatchford 2009, Purdon 2016,). However, Neale and Pino-Pasternak (2017) discussed that opportunities for ‘implicit’ learning are often overlooked and highlighted the importance of increasing opportunities for sustained shared thinking in ECEC provision. The ‘Talking Science’ intervention provided a socio-constructivist, experiential approach with the participants, in order to model and highlight sustained shared thinking in the context of ECEC science.

The SSTEW quality rating has been designed to measure sustained shared thinking in terms of adult–child interactions (Siraj *et al.*2015). The SSTEW method used to measure quality in the 16 Flying Start settings involved in 'Talking Science' can be seen in Waters and Macdonald (2018). In brief, adult-child interactions were observed over a complete Flying Start session of approximately 2.5 hours in each individual Flying Start setting. The interactions observed were rated using the SSTEW rating scale for 2-5-year-olds provision (Siraj *et al.* 2015). The SSTEW rating scale is subdivided into 14 Items each of which is separately rated from 1-7. A rating of 1 is considered inadequate, 3 as minimal, 5 as good and 7 as excellent.

The SSTEW findings highlighted that adult-child interactions linked to *Supporting learning and critical thinking*: Item 9 *Supporting curiosity and problem-solving;* Item 11 *Encouraging sustained shared thinking in investigation and exploration;* and Item 12 *Supporting children's concept development and higher order thinking* were the least developed aspects of practice. The average score for settings was below minimal across the three items, rated at 2.2 (item 9); 2.1 (item 11) and 1.1 (item 12) (Waters and Macdonald 2018). The participating Local Authority identified the lowest scoring items of the initial SSTEW observation as a basis for targeted professional learning, in line with their strategic remit to 'develop and deliver professional learning to childcare professionals' (Welsh Government (WG) 2014, p. 9). Furthermore this allowed the authors of this article the opportunity to develop a targeted cost effective model of professional learning based on the STTEW data and the pedagogical practice observed by practitioners (who subsequently attended 'Talking Science'). SSTEW Items 9, 11 and 12 reflect the child-adult interactions which support science concepts and learning. As these were the lowest scores, and in light of the fact that the current ECEC curriculum in Wales, 'The Foundation Phase' (WG 2015), suggests that the role of the adult in developing children's early skills in science and concept development is crucial, 'Talking Science' was considered a significant opportunity for professional learning by the Flying Start advisory leads responsible for allocating and supporting professional learning.

The 'Talking Science' professional learning intervention

The three key aims identified for the 'Taking Science' professional learning were:

- gaining insight into participants' own perceptions of science;
- facilitating discussion of current practice and practitioner confidence linked to science concepts; and
- providing practical opportunities to engage with and reflect on science in an ECEC context

The first two aims were to identify the opportunities, barriers, misconceptions and fears held by participants in relation to science. The third aim was to provide the research team / experts the opportunity to model and reflect on engaging with ECEC appropriate science pedagogy. 'Talking Science' was designed to address the issue of 'meta-cognitive talk' and 'modelling thinking' that participants could then develop in order to engender curiosity, discovery, problem solving and sustained shared thinking in their settings and thus provide solid foundations for children's development as young scientists (Brunton and Thornton 2010).

The format of the 'Talking Science' professional learning programme compromised of two half days, each of 4 hours, three weeks apart. Day 1 included sections that: acknowledged current practice and confidence; enabled participants to think about science and interpret what science meant in their own context; enabled hands on participation in practical work linked to sinking and floating; enabled small group and whole group discussion; developed skills in meta-cognitive talk and modelling thinking, and supported practitioners with planning science activities for conducting in forthcoming weeks, which they would film record and reflect on with colleagues within their setting, in preparation for Day 2 of the professional learning.

Day 2 included sections that: allowed the practitioners to reflect and share experience of conducting the planned and filmed science activity; enabled all to partake in a carousel of indoor and outdoor ECEC activities, focusing on forces, biodiversity and the water cycle; revisited their earlier interpretations of science from Day 1; and re-evaluated their approach to science in ECEC.

Research aims

The aim of the empirical research in this article was to consider the implications of a professional learning model designed to provide a forum for ECEC practitioners to be able to learn experientially and reflect in a socio-constructive learning environment. A longer term evaluation of the 'Talking Science' intervention has been evaluated by Waters and Macdonald. (under review).

Methodology

Research Context

The research was undertaken in accordance with the University of Wales Trinity Saint David's (UWTSD) Research Ethics and Integrity Code of Practice and was ethically approved by the UWTSD's Procedures for the Ethical Approval of Research Projects. The British Educational Research Association (BERA), 2018 Ethical Guidelines for Educational Research were used to design and complete the research. This included ensuring all participants provided signed voluntary informed consent, and the identities of participants and their settings were not disclosed as part of the research findings or subsequent publications.

Professional Learning Programme Design and Theoretical Context

Participants

A total of 64 participants attended the professional learning representing all staff (managers and others) from 16 Flying Start settings across one Local Authority in Wales. All participants were female ECEC practitioners and were qualified in line with SCW regulations for Flying Start settings.

'Talking Science' was a two-day event with the participants from Day 1 returning for Day 2. Given the large number of participants from across the Local Authority, the two-day professional learning intervention (Day 1 and Day 2) was run twice: 36 participants attended one run of the professional learning and 28 participants attended the second run.

Data Collection and Analysis

Data collection and analysis was interpretive in approach, and the data collected was qualitative, since the focus was participants' perceptions of science and ECEC practice. Three research tools were used to collect data during 'Talking Science'.

Research Tool 1: Small group activities and discussion formed a fundamental part of the 'Talking Science' content. Self-selected groups of participants ranging from 4-10 people in size were asked at the beginning of Day 1 and again at the end of Day 2 to discuss their thoughts and ideas on three questions:

What is science?

How do you feel about science?

When do you do science with your children?

These questions provided the initial prompts to encourage reflection and the sharing of ideas. One data collector from the research team sat with a group, ensuring that each group had a researcher observing the group's discussion. Each data collector listened, observed the discussions, and scribed the key points highlighted. Discussions were not audio or video recorded as this might inhibit the free flow of discussion and willingness of participants to contribute. Therefore, the text scribed by the researchers were written as fully as possible but were not verbatim. This data collection tool was used alongside research tool 2 below.

Research Tool 2: The participants' own written feedback from group discussions (noted in research tool 1), was also collected on Day 1 and Day 2 in the form of participants own handwritten flip chart notes. The participants in each discussion group scribed their own flip chart text summarising their discussions.

The data collected using research tools 1 and 2 included the researchers' scribed text together with the participants' flip chart text. The data was qualitative and explored the participants' perceptions of science at the beginning of the professional learning on Day 1 and after the professional learning on Day 2. The scribed text collected by the researchers was not checked by members of the group for accuracy, however as noted later in the Analysis section it was analysed in conjunction with the groups' own flip chart notes so that the data in the researchers' text were consistent with the participants' text.

Research Tool 3: participants were given an evaluation sheet of four open ended questions that individual participants completed at the end of Day 2 of the 'Talking Science' intervention. This tool was designed to evaluate the professional learning programme. Questions explored key issues linked to: the most useful aspect of the professional learning; aspects of the professional learning that participants would adopt; aspects of the professional learning that they found confusing/unclear; and suggestions for improvements to the professional learning.

Analysis

The feedback recorded as written text by the researchers (research tool 1) and the flip chart text (research tool 2) were transcribed and checked with individual data collectors for consistency and accuracy. A deductive thematic analysis approach was used to identify themes (Braun and Clarke 2006) Identification of themes was informed by the research literature and existing knowledge of ECEC (see literature review). Thematic analysis involved initially coding specific phrases within the transcripts. Codes were then drawn together into specific themes. Themes were reviewed and finally named and defined for clarity and understanding. Data collected for Day 1 (researcher scribed text and flipchart text) were initially analysed separately for each run of the professional learning. However due to the consistency of themes identified for Day 1 on both runs, the data was amalgamated and coded and themed as one data set. Similarly the data for Day 2 (researcher scribed text and flipchart text) for both runs were amalgamated and analysed as one data set. Three themes were identified:

- Complexity, confidence and past experience
- Perception of science,
- Delivering science in ECEC.

The data from the evaluation forms (research tool 3) were analysed as one data set for both the two runs. As the participants had provided extended written answers all forms were analysed in relation to the themes highlighted in research tool 1 and 2 as well as in relation to specific professional learning outcomes, participant insights and the literature context that supported the discourse within the two days of training. Waters and Macdonald. (under review) have also undertaken an online questionnaire survey evaluating ‘Talking Science’ in further depth. For all data sets, the original run group was identifiable. Discussion groups on Day 1 were numbered 1-10, on Day 2 numbered 1A-8A: and individual evaluation forms were numbered Participant 1-64.

The researchers’ scribed group discussion text were not complete verbatim records of the discussion; therefore, for consistency the themes identified within this text were crossreferenced to the text provided in the flip chart text. The researcher's scribed text was transcribed as accurately as possible, but was not a verbatim transcript. Thus when presenting participants feedback in the discussion section, single quotation marks were used to highlight excerpts from the transcripts.

Findings and Discussion

Complexity, Confidence and Past Experience

Day 1 discussions of science were more varied than Day 2 discussions, in terms of acknowledging both positive and negative aspects of participants' experiences and perceptions of science. Participants' past experience at school; perception of science as complicated or difficult; and their own confidence in supporting science learning in practice; formed a significant part of all Day 1 group discussions. Group 2, referred to science as '*scary, strange, confusing*', whilst Group 3 noted '*panic*' due to being '*under confiden*t'; with one participant noting '*I don't know how things work*'. Similarly, a member of Group 4 highlighted '*At adult level it is scary*' suggesting this was due to '*not knowing if all the information was correct'*. Other groups also suggested they were nervous and apprehensive of science. Day 1 group discussions suggested that current confidence was interlinked with their own past school experiences, for example, *'Secondary school experience was not always good*' and '*Don't always know if what you learn is relevant*' (Day 1 Gp 4); similarly '*I don't know much science*', linking this to her '*own bad experience*' at school. (Day 1 Gp 7).

Group discussions also explored how school experiences of science had led to worries of 'getting it wrong' and 'wanting to be right'. There were some participants in different groups who noted they 'hated' science at school. Group 9 highlighted that the term 'science' was a '*turn off*' and that they were apprehensive about it. However, the same group discussion also suggested '*science doesn't have to be scary*'. Group 8 discussions also resonated noting that science '*Until broken down it's complicated…. Made fun when simplified'*.

Sunberg and Ottander (2013), in a Swedish preschool within a student practitioner professional learning context, noted similar negative perceptions of science at school. As highlighted in the literature review of this study, there is concern regarding a negative attitude towards science in adults (Jenkins and Nelson 2005, Lyons, 2006, Lyons and Quinn 2010) where experiences of school science can affect later interest in science (Cleaves 2005, Lyons 2006, Stake 2006, Aschbacher *et al.* 2010). Some of the views expressed by participants in this research suggested that this is reflected in the Flying Start ECEC sector.

The notion of science as being complicated was also discussed, on Day 1, specifically related to working with young children. A participant in Group 3 suggested that science may be too complicated as the children she worked with were only two years old. Another participant similarly noted '*We don't want to confuse the children either. Sometimes it is difficult because of the language barrier*' (Day 1 Gp 6). Discussion by Group 9 suggested that it might be '*Too complicated for little ones….When I think of children we're aiming too high*'. Yoon and Onchwari (2006) and Metz (2009) noted that practitioners avoided teaching science as they viewed it as difficult and too hard for young children. Participants in our research study suggested that practitioners would need to think more when trying to explain scientific ideas, and that they did not have the confidence or education to do this. Group 8 also considered the language used when discussing science concepts, debating whether they should use the correct scientific terminology with young children and the benefits of simplifying words. The participants acknowledged this was a complex issue. However one participant noted '*I don't see the word 'dissolve' as scientific*' (Day 1 Gp 8) indicating that this was a word she currently used with young children. Saçhes (2014) suggested that practitioners who perceived children as competent of learning science concepts were more likely to teach them science. Cremin *et* *al.* (2015) suggested that the perception of early years education as important means young children are increasingly viewed as being interested and competent in science. Duschl *et al.* (2007) and Metz (2009) suggested that when developmentally appropriate science experiences are offered to young children they foster a lifelong positive attitude to science and that developing practitioners' confidence and positive perception of young children's abilities could lead to positive science outcomes (Metz 2009, Edwards and Loveridge 2011).

On Day 2, some of the negative issues linked to confidence were not visible within the discussions or flip chart feedback. Discussions on Day 2 rather focused on the opportunities available to explore science and their positive feelings towards engaging science in their practice. Group 1A used the keywords '*confident, positive, excited and eager for new experiences*'; similarly Group 6A noted that they felt '*excited, intrigued, unsure, fun, keen and more relaxed*'. Group 7A noted they were '*more confident, had more understanding and that it was ok to not know everything*'; whilst Group 8A suggested they were '*confident, excited, enthusiastic, knowledgeable, happy, and prepared*'. The initial SSTEW findings, which led to this study, noted an absence of the exploration, problem solving and higher concepts related to science. This is in line with Tu (2006), Tu and Hsiao's (2008) findings that science did not feature highly in preschool practitioners' subject preferences, and thus they rarely engaged in science instruction. Since the 'Talking Science' professional learning was designed to support participants to encourage sustained shared thinking linked to science, this discussion might suggest key professional learning messages had been shared successfully with participants. Bleicher (2007), Osborne and Dillon (2008) and Rosenfeld and Rosenfeld (2008) suggested professional learning should address attitudes and beliefs regarding science. 'Talking Science appeared to have supported participants to deconstruct and reflect on their attitudes and beliefs in relation to science, providing a platform to reconstruct and consider alternative approaches.

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Perception of Science

On Day 1, participants described science in the context of their past educational history. 6 of the 10 groups on Day 1 discussed science as it was delivered in secondary school, referring to science as '*Biology. Physics, Chemistry'*. One noted science to be '*what you do when you go to school'* (Day 1 Group (Gp) 4). Individuals noted such things as: '*That's what came to my mind-the periodic table*' (Day 1 Gp 2); '*Maths equations, elements'* (Day 1 Gp 8); and '*Bunsen burner: that's what I think about when I think about science*' (Day 1 Gp 9).

Some perceptions were linked to the portrayal of science in wider society, for example, '*NASA, Labs, space, forensics….men in white coats*' (Day 1 Gp 6) and '*Professors and Einstein'* (Day 1 Gp 9); coupled with linking science to intelligence e.g. *'intelligent and clever people'* (Day 1 Gp 2) and '*intelligent 'geeky' people*' (Day 1 Gp 3). Andersson and Gullberg (2014) discussed the feminist perspective that science has been given a hierarchal and elitist status in some Western societies. All participants in this research were female which reflects the significant female bias within the ECEC workforce (DfE 2011). Andersson and Gullberg (2014) suggested that giving science a high cultural status could lead ECEC practitioners to lack confidence. This may be confounded, where understanding science concepts, rather than having positive feelings from science experiences, is the cultural focus of education.

Some group discussions suggested that science was part of the everyday for example, '*We do it automatically but don't realise its science'* (Day 1 Gp 3) and '*We do things in work which are science, but don't think of them as science*' (Day 1 Gp 4). However, some also related science to being 'different or 'special'. The data demonstrated that the perception of science in the everyday, rather than science as 'special', dominated the discussion on Day 2 for example, '*All play involves an element of science*' (Day 2 Gp 4A) and group 5A suggesting '*Science is simple'*. No group discussions on Day 2 linked science to intelligence, with all groups' flip chart feedback linking science to ‘everyday life’. There was a shift in discussion content and focus from Day 1 to Day 2. All groups recognised the significance of science as something in the everyday on Day 2. This aligned with the reframing of science, highlighted by Philippou *et al.* 2015, suggesting that this aspect of ‘Talking Science’ was successful in transforming their perceptions. Group discussions also resonated with Andersson and Gullberg’s (2014) research suggesting ECEC science learning is not concept driven. All Day 1 groups, when discussing science, included key words such as ‘*exploring, discovering, experimenting, testing, curiosity, observation, problem solving, fun’*. Such features of science were also noted on Day 2 and could be viewed as the skills of science, which Brunton and Thornton (2010) suggested, are the platform for deeper science concept development.

The identification of curiosity and fun, suggested that for some participants, science was deemed a positive and interesting pursuit; supported by ‘*My teacher made it really interesting*’ (Day 1 Gp 3) and a discussion of science as ‘*thought provoking’* (Day 1 Gp 5).

Several group’s discussed science as being sensory, for example, Day 1 Gp 6 noted that ‘*all sensory is science*’, providing the example of children playing with ice. Another participant in Group 8 discussed potion making, and Group 9 discussed providing new experiences linked to ‘*smelling, touching and using senses’*. Andersson and Gullberg (2014) suggested that those working in ECEC, teaching science, should support curiosity and playfulness. ‘Talking Science’ also provided examples of finding the science in play and play activities with participants noting the value of this practical and experiential approach to professional learning. Participant (P) 55 wrote in the evaluation questionnaire ‘*Taking part in the practical activities highlighted that even as adults you do not always know the answers’*. Participants highlighted the sinking and floating activity on Day 1 as a valuable example that demonstrated explorative learning and the use of questioning. Cremin *et al.*’s (2015) empirical research across 71 early years’ classrooms with 3-8 years old, in nine European Union countries concluded that in ‘playful motivating and exploratory contexts, young children often supported by their teacher, engage with resources, ask questions, collaborate and find and solve scientific problems’ (p. 416) which also reflects the approach in ‘Taking Science’. Van Aalderen-Smeets and Walma van der Molen (2015) suggested that professional learning, demonstrating that science could be inquiry based learning, where children are active learners who respond to problems and scenarios, alleviated practitioners’ anxieties, and this appeared to resonate with practitioners’ feedback in ‘Talking Science’. Nuttall *et al.* (2015), Philippou *et al.* (2015), Perry and MacDonald (2019) have also suggested that reframing challenging areas of the curriculum in line with a practical, play based pedagogy could support transformational professional learning.

Delivering Science in ECEC

Day 2 group discussions and evaluation feedback suggested that several participants’ initial view of science as a specific subject linked to the school curriculum (as outlined previously) had evolved to viewing science in the everyday, and as part of the natural play and activities within the settings. Evaluation data supported this with P 16 noting ‘*Given lots of ideas of using science and realising that we do use it every day in the setting*’. P 34 suggested that the professional learning had been useful in ‘*incorporating science and questioning into everyday practice*’.

Group 10 provided examples of opportunities to explore science concepts during cooking, outdoor learning and ‘welly walks’, changes in the weather, recycling, planting and looking after pet fish, water play and construction play. Evaluation data supported the notion that science concepts could be explored in child-initiated play and serendipitously. For example, ‘*allow the children to explore as opposed to stop them from doing something*’ (P 47); ‘*Explore with the children activities which may accidentally happen*’ (P 48); and ‘*Allowing children to take the lead and follow through with questions relating to science*’ (P 41). Pendergast *et al.*

(2017) also suggested a need for positive practical support, where play based science activities are modelled as part of professional learning and Siry *et al.* (2012) demonstrated that children had a complex understanding of scientific concepts when they engaged with others in everyday experiences.

Andersson and Gullberg (2014) identified four skills that preschool practitioners can develop when teaching science; one being ‘capturing unexpected things that happen at the moment they occur.’(p.42). The data collected from practitioners suggested a willingness to engage with this skill. Talking aloud (metacognition) was explored in the professional learning and appeared within Day 2 discussions and in the evaluation data for example, ‘*Talking out loud! –seems strange to do, but observed the children get a lot out of it*’ (P 43) and ‘*Talking about what you think is happening to the children out loud…. Going on a journey with the children’*. (P 23).

Another topic emerging in Day 2 discussions and in the evaluation, was how adult questioning can scaffold and support children to engage with science concepts. Group 2A suggested asking questions to extend the children’s knowledge and to encourage children to find out ‘why’ things happen. This was supported in the evaluation data, ‘*Pausing when I ask a question, in order for them (children) to process the information*’ (P 43); ‘*I will be much more open minded during free play and activities with the children and talk about my own thoughts and interest in what might happen’* (P 29) and ‘*Thinking out loud to encourage the children to talk about their own thoughts and feelings’* (P 63). Siry and Lang (2010) discussed the benefits of exploratory talk when supporting children’s understanding of science concepts and how adults play an important part in facilitating and enabling this talk. Wright and Gotwals (2017) found that young children, when receiving support and appropriate scaffolding, participated in sophisticated science talk. The findings from the evaluation and Day 2 discussions suggest the participants had identified the significance of questioning and metacognition as part of their role in scaffolding science learning.

The evaluation data suggested a view that science was not always about being right, but was a process of learning e.g. '*Discovering that it doesn't matter if I don't know the answer to science activities / topics, it's more about going on the journey with the children and how following their lead can introduce the most exciting thinking process*' (P 29); '*having the confidence to know that it's ok not to know everything*' (P 28); and '*More confident in pursuing questions to find the answers. To speak out loud with children as I won't know the answer to everything*' (P 30). Andersson and Gullberg (2014) suggested that finding one's own answers to questions through observation and investigation can be empowering and that practitioners supporting children to find things out for themselves can support the children's confidence and self-esteem. Not feeling that they have to be 'all knowing' and having the confidence to ask questions may support ECEC practitioners to develop the child's own confidence to investigate as well.

Conclusion

Philippou *et al.* (2015, p.5 cited Stoll *et al.* 2006) suggested that learning within professional learning communities 'involves active deconstruction of knowledge through reflection and analysis and its reconstruction through action in a particular context as well as co-construction (of knowledge) through collaborative learning with peers'. The data collected on Day 1 of the 'Talking Science' intervention provided evidence that this was also the case for participants in this research study. Negative perceptions of science were not visible at the end of the Day 2 professional learning session, suggesting that the socio-constructivist and experiential approach used during 'Talking Science' allowed participants to deconstruct and reconstruct attitudes and beliefs towards science in practice. However, without viewing practice, the longer-term impacts cannot be verified and as noted by Wei *et al.* (2009) professional learning without follow up may be ineffective in changing science facilitation and teaching. Waters and Macdonald. (under review) have undertaken a follow up study 6 months to 1 year after the 'Talking Science' intervention which suggests some improvements in the SSTEW items targeted by 'Talking Science' and providing initial evidence of a sustainable and transformative intervention supporting the design of a socio-constructivist, *en masse*, targeted model.

Andersson and Gullberg (2014) suggested that science education in preschool is not concept driven and instead is linked to exploration and encouraging questioning and curiosity. Participants in 'Talking Science' recognised the opportunities to explore science in everyday setting activities and play, and also highlighted this 'discovery' aspect of science. Participants also suggested that not being expected to know everything about science and developing their questioning and metacognition skills encouraged their confidence to explore science with children. This research therefore suggests that professional learning that: explores practical examples; models questioning and highlights the opportunities for learning that come from 'not knowing', also support participants to develop more positive perceptions of ECEC science. Pendergast *et al.* (2017) noted the benefits of providing professional learning in science that also links to the pedagogy used in practice, and this would appear to be supported in this research study where participants were involved in activities such as water play, nature activities and small world play. Furthermore, participants who note negative experiences of science, especially during secondary education, may benefit from professional learning that is designed to model ECEC pedagogy, as it can make science teaching more meaningful and accessible, and change some of the negative perceptions practitioners already hold. As highlighted by Nuttall *et al.* (2015) in terms of ECEC professional learning, reframing digital technologies within play supported ECEC practioners engagement with this area of the curriculum. This suggests that professional learning that is pedagogical as opposed to only subject based is an effective model for several other challenging ECEC curriculum areas.

ECEC practitioners play a significant role in engaging young children's early interest in science and problem solving (Metz 2009, Edwards and Loveridge 2011) thus professional learning that encourages them to see the opportunities to explore these areas could provide significant long term benefits for ECEC more generally. The REPEY study (Siraj-Blatchford *et al.* 2002) demonstrated the correlation between the quality of ECEC provision and the long-term attainment of children. Higher practitioner qualifications and professional learning, as well as the quality of adult-child interactions were correlated with high quality provision (Siraj-Blatchford *et al.* 2002). Furthermore, in the current economic climate, where Local Authorities may need to carefully consider the funding available to support continuous professional learning within the ECEC sector, specialised professional learning designed in response to a SSTEW or similar evaluation exercise would offer an efficient and focused approach to professional learning (Waters and Macdonald under review). More broadly the model presented here involved collaborative professional development between practioners at all levels of a cluster of settings with a team of external experts allowing for a cross-disciplinary approach. Attendance was *en masse* as opposed to a cascade model, with space for socio-constructivist learning, delivered experientially. The intervention also supported reflective practice. Hadley *et al.* (2015, p.190) suggests the importance of 'professional learning that is 'government funded, facilitated by experts and systematically coordinated and evaluated, making it possible to assess achievements of a planned PLD'. 'Talking Science' reflected Hadley *et al.*'s approach and thus provided a systematic, transformative and sustainable intervention (Waters and Macdonald. under review) due in significant part to the flagship status and government funding provided Flying Start. However the diverse nature of the ECEC landscape in terms of providers and funding may make this model difficult to support where funding an *en masse* model, to allow all ECEC practioners to attend, is not financially feasible.

Ironically without such an *en masse* model, the development of collaborative, socio-constructivist approaches to professional learning are challenging to sustain.

Limitations and Future Work

The specific research study presented here was a small scale snap-shot and was based on participants' own self-reporting, and thus cannot be generalised or used as a means to measure or qualify how participants used the messages and experiences from the professional learning in their own practice with children. Neither can it explore long-term effects on practitioner practice or perceptions of science. However Waters and Macdonald. (under review) suggest the 'Talking Science' intervention had positive outcomes in practice. The socio-constructivist approach used in the professional learning could also be critiqued, as the data collected from the group discussion, flip chart content and evaluation on Day 2 reflected the main messages and aims within the professional learning, which could indicate that participants were responding to what they 'thought the trainers wanted to hear' in line with response bias. However, this approach to professional learning, where participants co-construct knowledge with experts and peers is also a strength of the approach in terms of valuing the experience and voice of the participants.

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