Talking everyday Science to very young Children: a Study Involving Parents and Practitioners within an early Childhood Centre

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Abstract

The acquisition of everyday scientific concepts by 3-6 year old children attending early childhood institutions has been widely studied. In contrast, research on science learning processes among younger children is less extensive. This paper reports on findings from an exploratory empirical study undertaken in a 'stay and play' service used by parents with children aged 0-3 and located within an East London early childhood centre. The research team collaborated with practitioners to deliver a programme of activities aimed at encouraging parents' confidence in their own ability to support emergent scientific thinking among their young children. The programme generated children's engagement and interest. Parents and practitioners reported increased confidence in their ability to promote young children's natural curiosity at home and in early childhood provision. The authors see no reason for positing qualitative differences between the way children acquire scientific and other concepts in their earliest years.

Keywords

Emergent scientific thinking; everyday scientific concepts; children aged under three; parental confidence; early childhood practitioner confidence

Introduction

The early years are a critical time for acquiring scientific concepts. Indeed, infants and young children are intuitive scientists, according to Gopnik (2009). In a paper for *Science*, Gopnik (2012) summarised the state of psychological research on scientific thinking in young children, while the acquisition of scientific concepts by 3-6-year-old children attending early childhood institutions in a variety of countries has been quite widely studied in the English language research literature (Greenfield, Jiroux, Dominguez, Greenberg, Maier & Fuccillo, 2009; Samarapungavan, Patrick & Mantzicopoulos, 2011; Guo, Piasta & Bowles, 2015). In a summary of the theoretical literature on children's knowledge construction from infancy onwards Goswami (2015, p. 6-8) referred to patterns of perception forming part of this process that can be defined as 'naive physics,' 'naive biology' and 'naive psychology.' She considered the evidence strong that:

> Dynamic inter-relations between objects perceived in the everyday world give the impression of causality. This perceptual analysis of the dynamic spatial and temporal behaviour of objects and agents appears to be one basis of knowledge construction by the infant and child.
>
> (Goswami, 2015, p. 5)

The practice, attitudes and perspectives of teachers and other early childhood practitioners form the main focus of some of the international empirical and survey research undertaken in early childhood provision (Siraj-Blatchford & McLeod-Brudenell, 1999; Leung, 2008; Kallery, Psillos & Tselfes, 2009; Erden & Sönmez, 2011; Spektor-Levey, Kesner-Baruch & Mevarech, 2013; Piasta, Yeager Pelatti & Lynnine Miller, 2014; Kambouri, 2015; Trundle & Saçker, 2015). Studies reporting on early childhood practice aimed at promoting emergent science among 3-6 year olds (Gelman & Brenneman, 2004; Fleer, 2009) may vary in their emphasis on teaching as compared to learning, even in play-based practice. The need to strike a balance between children's spontaneous or 'discovery' learning of scientific concepts and teacher input in early childhood settings was well articulated by Siraj-Blatchford:

> ...to be educational in terms of science some form of instruction (e.g. demonstration, modelling etc.) is usually needed, and clear objectives need to be defined. From the simplistic notions of individual cognitive elaboration through 'discovery' we have therefore increasingly come to see child development in socio-cultural terms as a 'construction zone' involving the educator and not just the child. (2001, p. 4)

Johnston and Tunnicliffe (2014, p.3) provided a definition of key characteristics of good early childhood practice in relation to emergent science. They considered hands-on science-based activities providing 'practical experience' of the scientific phenomenon under study as essential for early learning, while regarding the provision of explanations of secondary importance or not yet needed. Taking a slightly different position from that of Siraj-Blatchford, they reminded practitioners and teachers that:

> Emergent science encourages young children to communicate and share their ideas with others... It does not limit children and neither does it advocate didactic teacher-led approaches; rather, it recognises that the best learning strategies often involve the practitioner 'standing back' and allowing children time and space for exploration...
>
> (Johnston & Tunnicliffe, 2014, p. 3)

Parents and other primary caregivers are generally recognised as the child's primary educators, particularly in the early years (Shonkoff & Phillips, 2000). Consequently a growing body of educational and psychological literature is devoted to the influence of parental scientific interests on the development of young children's interest in science (Leibham, Alexander, Johnson, Neitzel & Reis-Henrie, 2005; Tenenbaum & Callanan, 2008). A few of these studies straddle the home and early childhood setting divide, such as a US doctoral study by Pattison (2014). In order to explore the emergence of scientific interest in the early years, Pattison undertook a survey of US Head Start parents and carers, followed by empirical research with seven mothers and their four year old daughters, who jointly took part in scientific activities both at home and an early childhood setting. This study complements findings from other investigations of emerging scientific interests among young children (DeLoach, Simcock & Macari, 2007; Leibham, Alexander & Johnson, 2013).

Research exploring how younger children acquire scientific concepts in either the home environment (Sikder, 2015), or via play-based activities in early childhood provision, appears to be less extensive compared to that focusing on the older pre-school age group. However, the Centre for the Advancement of Informal Science Education in the USA, an initiative of the National Science Foundation, recently produced a useful compilation of research and other resources on the role of parents and caregivers in early science learning (CAISE, 2013).

Generally, fewer early childhood practitioners working with the youngest children have full teaching qualifications than those working with children aged 3-6; in England qualified teachers may be working with under 3s, but this is not a requirement. Their level of scientific knowledge may be different, which may affect their ability to transmit this to children in their care, which may put them on a par with some parents. In a research-informed early science textbook for British early childhood practitioners, Tunnicliffe (2013a) included two-year-olds within its remit and her work with very young pre-schoolers was further developed in another publication aimed at this practitioner readership (Tunnicliffe, 2015).

Language plays a definitive role in enabling children's acquisition of knowledge of the world at any stage of early development (Nelson, 1998). In the earliest years children show considerable variation in the rate at which they acquire productive vocabulary; they may be understood well only by familiar adults like their parents. Nevertheless, their attention can easily be drawn to new targets of attention shared with those close to them and the use of language in this process is crucial (Nelson, 2008). Nelson took issue with theorists like Gopnik who saw the child as budding 'scientist' from birth. For Nelson, the metaphor of 'the experiential child' seemed more apt in the light of children's primary reliance on relationships in experiencing and exploring the world around them:

> This child actively seeks meaningful experiences relevant to her current needs and interests and makes pragmatic sense of her encounters in the world, in close relation with adults who care for, support and guide her.
>
> (Nelson, 2008, p.1)

It is in early childhood services for the very youngest children that parents may be involved alongside practitioners in elements of the programme, which could include science activities. For instance, in informal 'stay and play' sessions in English early childhood provision. 'Family science' work with parents has also been reported within a primary school context (Watts, 2000). But we located few studies addressing the issue of introducing very young children to science in partnership with parents within early childhood services.

The study

The present article reports on a small empirical study of emergent science conducted with parents and carers[1] with children aged 0-3 within a multi-functional London early childhood centre. This included a nursery school (kindergarten) for 3-5-year-olds as well as a Children's Centre, also known as a Sure Start Children's Centre (Bate and Foster, 2015), which offers various play, early childhood education, health, parenting and other family support services to parents and children living in disadvantaged circumstances.

[1] From this point in the paper the term 'parents' will be used to denote mothers and fathers as well as informal carers such as grandparents formal carers such as family day care professionals (childminders) who use early childhood centre services

The study was developed by staff in an Education department at a London University which had for some time been promoting the importance of STEM (Science, Technology, Engineering and Mathematics) subjects. Funded by the university itself as part of its 'civic engagement' programme, the study's objectives included building partnerships facilitated by university staff which would benefit students and communities and undertaking a simple 'before and after' impact evaluation.

To investigate emergent science the research team designed a month-long programme of STEM-related activities to deliver during 'stay and play' sessions alongside centre practitioners. Working within an interpretive paradigm, the research team were guided by the following primary research question: would the programme generate evidence of increased parental confidence in their ability to support their children's emergent scientific thinking. To this end the research team aimed to help parents realise, for instance, that activities they might undertake at home with their young children, such as cooking and baking, were essentially 'scientific.'

Underpinned by Gopnik's (2009) theory of children as natural scientists, the study aimed to encourage parents to build on the natural curiosity of their very young children to explore aspects of the living world around them. From a theoretical perspective, the research team further intended to explore how 'scaffolding' –using the concept developed by Vygotsky (1978) – of the children's scientific thinking could be achieved through sensitive intervention and 'sustained shared thinking,' a process first theorised and promoted by Bruner (1977).

Emergent science can be interpreted as a form of 'understanding the world' one of the seven interconnected areas that statutory guidance from the English Department for Education requires English early childhood teachers and practitioners to implement as part of the Early Years Foundation Stage (EYFS) (DFE, 2014). This framework programme for early childhood provision for children aged 0-5 includes the welfare and learning requirements for registered early childhood services and guides their inspection by the Office for Standards in Education, Children's Services and Skills (Ofsted).

Although not explicitly mentioning early science, the EYFS 'understanding the world theme:

> ...involves guiding children to make sense of their physical world and their community through opportunities to explore, observe and find out about people, places, technology and the environment.

(DFE, 2014, p. 8)

The programme of scientific activities in the present study was in harmony with EYFS guidelines.

Our study was modelled on an early childhood STEM initiative pioneered a few years previously in rural Bangladesh by Tunnicliffe (2013b). Accepting that the early years are a critical time for acquiring scientific concepts (Tunnicliffe & Ueckert, 2011; Tunnicliffe, 2013a), Tunnicliffe's project aimed to demonstrate how parents can support their children in this process, for instance through observation and talking. Parents' role is enhanced if they are made aware of the extent of their own existing STEM related knowledge by being in turn supported by knowledgeable early childhood teachers and practitioners. Tunnicliffe's original initiative was developed to mark the 2010 Commonwealth Year of Science and Technology.

Research design and methods

In designing the study programme and its evaluation, the researchers did try to replicate features of the Bangladeshi model. Data gathering was therefore planned on the experiences of children, parents and centre practitioners directly involved in the early science programme's delivery, as well as on the experiences of staff and student members of the research team involved in delivering the early science programme.

The research team

The research team was made up of five School of Education staff members engaged in teaching and research in early or primary education or in early childhood studies. Three also had experience in early childhood practice as early childhood teachers or practitioners; in contrast two had a research background. The three experienced practitioners took the lead in planning the programme of science-related activities and in data collection, while two of them delivered the programme sessions. The two undergraduate students recruited to the team were also qualified early childhood practitioners and took part in scientific programme delivery alongside university staff, but did not participate in data collection.

The two researchers did not take part in the STEM programme's delivery or in data collection; their role was confined to study and evaluation design, data analysis and write-up. Dr Tunnicliffe agreed to act as scientific advisor to the study.

The early childhood centre and practitioners

The study took place in a Local Authority early childhood centre in East London in an area whose population is ethnically diverse and where rich live in close proximity to poor families. The centre's service used for delivering the research programme was a 2.5 hour 'stay and play' session run twice weekly during school term time for children aged 0-3 and their parents and formal or informal carers, such as grandparents or childminders (professional family day carers). These relaxed play sessions are free of cost and parents can attend when they wish, though required to register at each visit.

All four centre practitioners directly involved in the 'stay and play' sessions had been trained to deliver the EYFS. Throughout the programme planning and delivery process, the researchers sought practitioner agreement on draft contents, communication strategies with parents and on evaluation tools and processes. Practitioners agreed to distribute advance information about the programme to parents, to answer queries and to provide where possible help with research questionnaires for parents whose first language was not English.

The programme of science related activities

Research team members designed a programme of activities, some table-top, for four 'stay and play' sessions during consecutive weeks in the early summer of 2015; each session lasted 2.5 hours. The activities took place simultaneously inside the room allocated to the 'stay and play' sessions and in the outdoor area reserved for them. The programme was planned around scientific themes. For the first three sessions the themes of 'forces', 'materials and their properties' and 'the living world' were used to inform the choice of activities.

The fourth and final programme session was designed to allow participating parents and children to review their experiences and complete the 'project books' they had been given at the first session. These were meant for notes on and pictures of science related activities undertaken at home in between sessions, as a record of scientific 'observations' made by the children or any thoughts children and parents had had on the subject. The second set of parent questionnaires was administered during this session, too.

The researchers had also compiled a list of scientific terms to be used and explained during the sessions and had prepared prompts and questions suited to the youngest children, aged 1 and 2, and to any older ones participating. To encourage parents to continue engaging their children in 'talking science' after each session, pertinent items such as bubble liquid, seeds and bulbs to plant and play dough recipes for use at home were distributed at the end of sessions.

Other play activities were on offer as usual during the sessions, should parents or children wish at any time not to take part in the activities put on by the researchers. Appendix A shows the outline programme and summary of activities, including planned relevant vocabulary, questions and observations geared to different age groups.

Research tools

Research tools developed to gather qualitative evidence included written parent questionnaires, with some closed as well as open-ended questions, and semi-structured interviews with the 'stay and play' practitioners. These were administered during a 'stay and play' session in the week preceding the start of the programme of 4 sessions, and at the end. All members of the research team involved in programme delivery also produced field notes, as their role precluded taking observational notes. Date from a semi-structured electronic questionnaire completed by the students before and after the programme and listed in table A were not used for the present paper's analysis.

The small programme size and its short duration prevented the collection of pre- and post-evaluation developmental data on the participating children. As the research team was still keen on capturing young children's responses, despite the barriers presented by their limited use of productive language, they made intermittent audio recordings during the 4 sessions, using Tablets.

The evaluation research tools and numbers of participants who completed them are listed in Table A.

The initial parent questionnaire gathered information about the children they brought along, but also included items about parents' experience of science related subjects at school, the level of their education; the meaning the word 'science' held for them; whether they had noticed their children investigating and exploring what could be called science and how confident they felt in supporting their children with this. Parents participating in the fourth and final 'stay and play' session were again offered a questionnaire, which focused on their and their children's programme experiences.

The simple topics covered in the pre-programme interviews with centre practitioners included their experience of science at school and any preferences; their highest qualification and length of experience; whether they had noticed young children in their setting exploring and investigating what could be called science and their confidence in talking about scientific subjects to young children. In the post-programme interview they were asked about their enjoyment of the sessions; new ideas for working in this way with children and with parents; if there was any aspect of the session format they wished to change and whether they now felt more confident about talking about early science with parents.

Ethical considerations

The study design was guided by the ethical guidelines provided by the British Educational Research Association (2011) and received ethical approval from the university's ethics committee. Every member involved in the programme's delivery had a valid and enhanced certificate from the English Disclosure and Barring Service (DBS)[2].

Before the administration of the initial questionnaire, parents were asked to consent on behalf of their children as well as themselves and assured that any information they provided would remain confidential. Information briefings assured parents that all planned science-

[2] The DBS agency is tasked with safeguarding vulnerable groups, including children by ensuring that everyone in direct contact with them is deemed suitable and has no pertinent criminal record.

related activities would be safe for young children. As different parents attended in the course of the four sessions, researchers and practitioners ensured as far as was feasible that these parents were also offered programme briefings and consent forms. The ‘stay and play’ practitioners also received a briefing and completed a consent form in advance of their interview with one of three researchers.

At the end of the programme practitioners made sure that all parents who had participated in any of the sessions were given a ‘thank you’ in the form of a high street shop voucher on behalf of the research team. Afterwards, the centre itself also received generous equipment vouchers in recognition of their valued participation in the study. No mention of these was made before or during the programme or in briefings, so that these vouchers could not be construed as an inducement to participate.

Analysis and results

Here we limit ourselves to an analysis of the data on the experience and impact of the project reported by participating parents and practitioners and some observations on participating children’s behaviour. Despite what looked at first sight like an extensive and diverse range of data, the amount of useable information gathered directly from parents and practitioners proved limited. The researchers’ field notes were extensive and formed an interesting additional source of information.

Parental participation

As Centre staff held a register of all adults and children attending, it was possible to work out the pattern of attendance for parents and children over the four weeks the programme lasted. In all 19 parents or carers attended at least one programme session and they brought along 26 children aged under 5. Only three parents, accompanied by six children, participated in all four sessions. Another three attended three sessions; seven attended two and six only turned up for one session.

The ethnic composition of the attendees at any programme sessions was varied, reflecting that of the surrounding community. Over half the children and parents had an ethnic minority background, suggesting that several languages were spoken at home and English was a second language for many of the parents.

The number of parents whose attendance was registered over the whole programme turned out to be more than twice the size of the number who completed questionnaires either at the programme's start or at its finish. Of the eight adults who completed the initial questionnaire, three were mothers, two fathers, one a grandmother and one a childminder. Between them they had brought along 11 children, ranging in age from 1 year and 2 months to 3 years. Of these three were girls, seven boys and one child's gender was not noted on the questionnaire. But from the information collected it proved impossible to determine whether these same adults proceeded to attend any of the following four programme sessions.

Background information about adults and children was only gathered before the start of the four STEM programme sessions and did not include parents' personal details. Although the parents' stated intention to do so is a good indicator, we cannot verify whether the identity of parents who attended any subsequent programme sessions corresponded to that of parents completing the initial questionnaire.

Parents completing the initial questionnaire were asked to mark it with a 'pseudonym' which they would re-use on another questionnaire they would be asked to complete at the end of the four sessions. This strategy did not prove successful. Therefore we were unable to match the two sets of questionnaires to look for evidence of change. Neither could we work out on how many sessions the reported parental experience was based.

Since data collected from the same parents before and after the programme were key to exploring any impact of the programme experience on parental confidence in talking everyday science to young children, causality could not be examined further. This analysis instead concentrates on qualitative data from each questionnaire, starting with the initial one.

Parental behaviour and perceptions

A question about their previous science education offered eight subject boxes to tick for four levels of education, from primary to higher, but only two of the parents had studied science at primary school. However, six out of eight indicated that they had studied the three core science subjects, biology, chemistry and physics at secondary school, while two had also learned general science at secondary school. Only one1 respondent noted learning no science at secondary school. A further three had studied some science at Further Education level; none at university. As for science preferences, only physics and biology generated any dislike among this small group.

The participating parents also recorded, both before and after the project, what the word 'science' meant to them. Initial responses included 'learning through exploration'; 'how things work, technology, humans'; 'chemicals' and 'biology, chemistry, physics.' Post-programme responses somehow seemed a little more thoughtful: 'it means exploring, experimenting. It is about finding out how things work e.g. how the sponge soaks in water or how the stone sink in water'; 'definitely discovery, testing things out, experimenting' or, perhaps surprising: 'science is the act of using the mind to imagine things and doing it or acting it.'

The initial questionnaire asked parents if they had noticed their child exploring and investigating in a way which could be called science; six out of eight respondents confirmed they had observed their children exploring and investigating in this way. They gave examples such as sand play, water and liquid play, shape sorting, trying to work things out, problem solving and colour mixing. All but one reported feeling confident in helping their children with such exploration and investigation, with only one reporting not being sure.

All five parents who completed the final questionnaire were unanimous in reporting feeling more confident and having enjoyed the sessions they attended, as well as learning from them. 'I learned about more fruits than I never heard of before. I learned that science is everywhere and in everything children do' was one of the replies; another referred to 'Different activities. Log rolling and marking with chalk, mealworms. Fruit tasting and looking inside for pop,' while a third related to their son's learning: 'My son learning new things like plants, animals and create things with water colours.'

Only two respondents had access to a garden at home and noted new ideas for using it: 'Doing gardening with him, exploring about insects and worms when the ground is wet' and 'Water play, doing different weights, looking under stones for creepy crawlies, log rolling, chalk.' A couple of parents without a garden nevertheless planned to replicate the seed planting by doing this on the balcony or indoors. Among activities liked the most were: 'All of it, interaction. The way children got involved' and a carer reported 'I really like all of them. That gave me some ideas to plan activities with the children.'

Because of the questionnaire matching problem, no conclusions can be drawn from this information about any change in perspective after attendance at programme sessions

The researchers' field notes offered insights into how parents behaved with their children, for instance how they were observed extending their children's learning. A father offered more information on the peas that the child was looking at and explained how 'mummy' used different varieties for different types of food. Parents engaged not only with their children, but also with the activities themselves; one mentioned not having heard before of certain fruits and vegetables used for one of the activities. This prompted further conversation with the researcher and the parent writing a list so they could buy these fruits and vegetables themselves.

In several field notes researchers observed parental curiosity about the activities and resources. It was also noted that, particularly during the first programme session, parents appeared not to interpret exploring or investigation behaviour displayed by their child as a kind of scientific activity; this is illustrated in the following quote:

> M (male aged 14 months) is waving his hands in the water, splashing and making waves. He is smiling and has a concentrated look on his face. I comment on how he is using his hands to make the splash and the waves, and show him that I can do this too. His mum comments that he loves to splash and does this in the bath and at the swimming baths. I comment on how so many children of this age love to see the impact of their actions, through cause and effect, and mum comments that he likes to do the same thing over and over again. I comment that this is like a scientist testing a theory, and mum laughs. Several minutes later when she is completing the questionnaire, she is unsure if he engages in scientific play, but states that he does like to explore.

While lengthy, this observation is reproduced here in full to illustrate the type of conversation that developed between parents and researchers.

Children's reported behaviour

Just over an hour of activity involving children was recorded in the course of the four sessions. Not surprisingly, these audio recordings on their own give only an incomplete impression of how these very young children responded to the activities on offer. Multiple factors were responsible for this complexity. The conversations frequently involved more than one adult, for instance a parent, a researcher and a child, or several children, most of them with limited language.

Whereas the audio recordings failed to do justice to the children's engagement with the scientific activities, they provided some interesting insight into adult interactions, even though it was not always easy to work out who was speaking.

Also, these recordings definitely suggested that most children became actively involved in the activities alongside their parents and other adults and appeared to find them fun and interesting. These impressions are strengthened by the contents of the researchers' field notes. Combined with parental observations on their children's enjoyment, these data constitute a useful source of information on the children's responses to the programme.

The following observations are taken from field notes. In several cases it appeared that the children initiated the activities around the tables or elsewhere and led the adults to support them. Adults would subsequently discuss the activity with the children and help them learn. For example, during a 'float and sink' activity they were observed asking the children pertinent questions and helping them identify other items that would float or sink, even though most of the children were not yet speaking intelligibly.

The parents continually supported their children's language development, some by alerting them to certain 'scientific' words. But on occasion neither child nor parent noticed when one of the researchers attempted to introduce scientific language into the play activity. From the interactions reported by researchers, it became apparent that these children enjoyed the activities and explored them actively. Thus the field notes corroborated the recorded evidence to this effect.

Several field notes reported that children showed an interest in different experiences and demonstrated reactions that could be interpreted as an awareness of scientific concepts. For example, showing an awareness of the different force that was necessary to push objects up an inclined ramp or gutter as well as the gravitational force when rolling objects down the ramp or gutter. This transpired in observations of children at times rolling objects like different sizes of toy cars with their fingers and at other times allowing them to roll free noting the different speeds and lengths it travels. During other activities the children's engagement and interest became evident from them picking up the object, for example a piece of fruit, and showing their parent or carer in a way almost suggestive of asking for further information.

Children were also observed trying to engage other children with activities; for example one boy tried to get a girl to smell a flower, actively pursuing her and modelling the behaviour of smelling the flower, repeatedly trying to get her to smell the flower. This is something the child's parent had previously been trying to get her to do.

Practitioner background and perceptions

Before the programme's start three semi-structured interviews took place with centre practitioners involved in the 'stay and play' sessions and four afterwards. The three initial interviewees had worked as early childhood practitioners for 30, 9 and 6 years respectively and each possessed different qualifications. These included a Bachelors degree in child psychology for one; for another a vocational diploma in childcare and a vocational diploma (NVQ level 3) in adult and child psychology; and an older (NNEB) early childhood care qualification for the third practitioner.

Initially, each practitioner confirmed having noticed children exploring and investigating in a 'scientific' way by for example using magnifiers, using sand, both wet and dry, water play, playing with cars, doing planting and observing bugs. They felt confident about helping children in their setting explore and investigate in this way as well as in talking to parents about early science. Indeed, one observed: 'it's important to have that discussion.' None had studied any science in further (FE) or higher education (HE), but they had studied various science subjects throughout their schooling.

Like the parents, practitioners were asked to comment on their preferred school science subjects. Physics was the least liked out of a range of eight science subjects encountered at primary or secondary school. The meaning of the term 'science' for the practitioners was also explored twice.

Initial responses included: 'Things going on around you, everything around you, science, water, experimentation;' 'Find out how things work, getting the answers;' 'Exploration, investigation, discovery, imagination. Making links, fun and curiosity.' In the final interview practitioner responses were more detailed and suggested a change in either confidence talking about science, knowledge or both. This is illustrated by a response like: 'Science. To me it's about exploring. Investigating. Discovering. And making sense of the world around us and why things do, why things happen the way things happen really. That whole curious approach.' And by another: 'To me it means exploring, learning new things about science. Yeah, just really overall exploring.'

The practitioners all reported having enjoyed the programme sessions. They also identified different elements that they particularly liked and would be incorporating into their future planning. The following comments illustrate how their participation had encouraged practitioners to think differently:

> The biggest part for me was about the approach to the activities including the language that was used. I think one of the challenges that practitioners have is being able to feel confident in the language that they use to help children make sense of what they're experiencing or what they're seeing. And within that, sometimes I see that if you're not confident that you can shut children down by becoming perhaps apprehensive or nervous that it's gone a little bit off script. So being able to have those open ended questions that get children to think about what they've seen or what they've experienced or to try moving an object in a different way to test what it is that they just did or saw I think is what I really took from it.

Another observed:

> One of the things that dawned on me a couple of weeks ago was … in the home area. That we've got these soft kind of cushiony fruits and vegetables and I was saying well actually, do we need those? Could we not replace those with real fruit? Real vegetables. Even if it's not all the time but for a period of time. To allow children to feel what those things are like. Chop them up. Have pieces. You know, structured aspects. So it's just made me think differently I guess about activities and how we present things to children and families.

At the programme's end, some also felt free to comment adversely on elements:

> I think that initially the planning side of it looked really rigid. However, what I thought was great was that there was this confidence that if a child wanted to take an activity in a certain direction that that was allowed and encouraged really. And the vocabulary went along with that.

Evidence for a link with practitioner confidence emerged from this quote:

> And the other strength of the planning was that there was the vocabulary box as well. So it gave you those hints and tips that, you know, you could bring vocabulary into it

that may be not, may be not your confidence level, but it was there so you could name some of the things that were happening to help support the child.

Practitioners also spoke of how participation felt like team work; this included the work with parents and children. Their feedback suggested the experience had helped them feel more confident when talking to parents about science. The response of other 'stay and play' colleagues had particularly impressed one interviewee: 'What I've seen them do is go off and research areas themselves...What's been great is seeing them motivated and thinking differently about activities and science that they can incorporate...'

Practitioners made a major contribution to consolidating each session's experiential learning by displaying the content of the previous week's session on a White Board, clearly labelling the focus of that week as well as putting up photos labelled with key terms. Some activities were also left in place for the children to explore independently on their next visit. Several expressed the hope that the programme experience would encourage centre staff to organise a 'science day' during the summer holiday scheme. Only longer-term follow-up could confirm whether these were to prove lasting impacts.

In their field notes, researchers failed to collect much evidence of practitioners trying to tune into the possible thinking processes of the children or to model the process of exploring, for example by asking questions such as: 'I wonder what will happen if...' It was noted that, in contrast, parents themselves did do this at times. Commenting on a child's play, researchers observed, could be more effective than asking questions, as this risked switching the focus of play from the child to the adult.

Discussion

The researchers' experience of delivering the programme and simultaneously collect evaluation data highlighted the challenges as well as the pleasures of this piece of 'real world research' as Robson (2002) would have defined it. Reflecting on our experiences nevertheless allowed us to draw some positive conclusions about the potential usefulness of our tentative findings. As noted in the introduction, early childhood centre-based studies of STEM-related work with children under three in partnership with their parents has not yet been widely reported in the relevant literature.

To date the majority of such studies focus on children aged three and upwards attending educational settings such as nursery classes and schools. This even applies to the majority of articles in the *Journal of Emergent Science*. Indeed, the Bangladeshi project informing the present study involved children with a much wider age range and none as young as two. In this respect our research could be considered innovative.

Limitation on the method of analysis stemmed from a rather too ambitious research design for a very small and exploratory study. The research design's drawbacks were possibly unavoidable, as these derived from the 'before and after' impact evaluation format imposed by the funder.

In the light of the unpredictable number of parents and children attending the four 'experimental' programme sessions, a rigid research approach was not considered feasible or desirable and no criteria were attached to this sample's selection. Instead the team decided to collect a wide variety of qualitative data in a relaxed manner.

In the research team's opinion this empirical investigation would have benefitted from being approached as a case study. Case studies, as Stake (1995) pointed out, generate multiple perspectives and contradictions within the data. Consequently, the mostly qualitative data were analysed as if they emanated from a case study.

The fluctuating nature of attendance at the 'stay and play' sessions meant that engaging the same parents throughout the study process proved impossible. We could not be sure that the few parents who reported changes in their confidence levels at the end of the programme were the same parents who completed the initial evaluation questionnaire; even then the sample would have been far too small to suggest causality.

Only three out of 19 parents attended all four sessions; only five parents completed the final questionnaire; only one parent returned their child's 'programme book' at the final session. This is not unexpected within the centre's 'stay and play' session context, where any participation is voluntary and unpressurised. There is limited research evidence on the optimal length of participation in early childhood programmes associated with short-term or longer-term impact on children's emergent science. In this programme, though, even attendance at only a couple of sessions generated enthusiasm and interest in science related activities among adults and the children they brought along.

Pertinent to the interpretation of our data was the fact that the study setting differed in important respects, such as staffing structure, from more formal early childhood services such as nursery schools or classes. Any replication of this programme should only be attempted in similar early childhood centre ‘stay and play’ sessions involving parents and children working in partnership with practitioners.

Crucially, all adult participants were broadly aware of the purpose of the special science-related programme offer. These ‘demand characteristics’ of the evaluation research situation, so well explained and demonstrated in the work of Orme (1969), would have predicted positive responses in the practitioners and among the parents. This is not to denigrate the value of their self-reports, but just to acknowledge again the possibility that they might have wanted to meet the researchers’ expectations, consciously or unconsciously.

The children’s centre head teacher had justified her participation on the basis that she and her colleagues tasked with organising the ‘stay and play’ sessions were interested in gaining experience of an innovative STEM-related approach to early childhood teaching and learning through this collaboration with a university research team. They were particularly keen to participate in this study as a means of improving their own methods of working with children and parents, while also exploring gender related benefits of an explicit focus on early science.

Practitioners had invested time and effort in facilitating the science programme and were likely to wish for discernible positive impacts on all participants. Having welcomed their involvement with the university researchers, they would have been less likely to report nil or negative impact on themselves or on the other participants.

It remains interesting nevertheless that some did explicitly refer to changes in their own thinking. Noteworthy is the practitioner quote referring to enhanced confidence as a result of the materials provided by the researchers: ‘...it gave you those hints and tips that, you know, you could bring vocabulary into it that may be not, may be not your confidence level...’ This could be considered a useful pointer towards possible STEM-related training needs of early childhood practitioners.

In a study of Cypriot early childhood teachers’ understanding of and response to children’s scientific preconceptions, Kambouri (2015) established that few studied science during their one year training course. This put them at a disadvantage as far as removing these particular obstacles to children’s conceptual development was concerned (Kambouri, 2015, p. 18). Early childhood teachers’ need for enhanced science instruction was also noted by Trundle and Saçkes (2012).

The same may have been true for the practitioners in our study, although the small number precludes explicitly linking their previous formal science learning to their observations on this programme. Their views did suggest, though, that the experience opened up new perspectives on how very young children can be introduced to science-based activities within the ‘stay and play’ setting context. This could be considered a valued outcome of our research.

At the outset we noted that the body of studies on the influence of parental strategies and interests on the emergence of young children’s interests, including scientific interests, is considerable (e.g. Leibham et al, 2005; Tenenbaum and Callanan, 2008; Pattison, 2014). As part of his two-phase study Pattison examined pre-existing scientific interests in seven mothers and found a relationship with their 4-year-old daughters’ ‘broad sustained interest’ in science-related activities(Pattison, 2014, p. 115).

Our data do not allow us to trace such effects in our own sample of parents, although we offered evidence of parental learning. In future research projects of this kind, this aspect should definitely be studied in greater detail. It may be that researchers and practitioners stimulated the greatest interest in the scientific activities on offer in those children whose parents’ own pre-existing interests enabled them to build more effectively on the ideas generated in the programme sessions.

The fact that the researchers involved in the delivery of the programme were also collecting the evaluation data was another unavoidable research design weakness. Their retrospective field notes were not equivalent to real time tracking observations, although valuable. For them, too, the research situation generated ‘demand characteristics,’ particularly in relation to the interpretation of parental and children’s behaviour.

The researchers’ field notes do suggest, however, that their own perspectives as experienced practitioners on supporting young children’s natural curiosity did not prevent them from noticing divergences between parental and practitioner strategies for promoting emergent science. This became evident from the nature of questions and encouragement used by parents as opposed to practitioners, as noted in the analysis of practitioner behaviour above and is supported in the literature. For instance, toddlers’ science concept formation within a family context was studied with the help of video technology by Sikder (2015). Sikder argued that supporting toddles’ scientific concept formation came easily to parents and generated no more problems for parents than support for other aspects of their young children’s development.

In a study of emerging scientific thinking in two and three-year-olds which also employed video technology, Forman (2010, p.2) categorised the first phase of early scientific thinking as 'sensing the problem.' This developed into 'inventing a strategy,' exemplified by the kind of experimental behaviour with toy cars on a ramp mentioned in the previous section, followed by' finding a class of causes' and beyond. Could videotapes have been more helpful than our intermittent audio recordings to trace similar stages of scientific thinking?

Undoubtedly, but given that researchers themselves were delivering the programme supported by practitioners, an early decision was taken that they could not also be expected to videotape the sessions. Moreover, the team did not subsequently have the time or resources to engage in the frame-by-frame analysis such recordings would have required.

Arguably, the programme did meet criteria associated with support for emergent science in early childhood and primary school environments used by children aged 0-8, as articulated by Johnston and Tunnicliffe (2014, p. 3). They warned against the use of 'didactic and teaching-led approaches' and described good practice that involved not only '...allowing children time and space for exploration...' but also '...encourages young children to communicate and share their ideas with others...'.

Finally, the question arises to what extent this scientific programme was faithful to the design of its Bangladeshi model. As already noted, children in our study were considerably younger. Although Tunnicliffe reported in some detail on the Bangladeshi project (2013b), her information, coupled with our study's particular context, was insufficient to ensure full programme fidelity in the present study, although its intentions were similar.

Conclusion and implications

Variation in linguistic and cognitive ability was one of the key differences between the children in our study and those in the older pre-school age group reported on in the literature on early science learning and teaching. Although their communications could not be reliably interpreted as reflecting emergent science, their observed behaviour provided tentative evidence. The fact that children's experience in the 'stay and play' sessions was mediated by familiar adults, their parents and 'stay and play' practitioners, seems to have facilitated their enjoyment, encouraged their natural curiosity and most probably generated some STEM-related learning.

Some of our evidence suggests that parental interaction enhanced the children's learning at least as much if not more than practitioner interventions; and not only because parents were more in tune with their children's limited use of language. We would like to interpret this as an argument for the value of such partnerships in STEM-related as well as in other early childhood programmes involving the youngest children.

At this stage of development children's natural curiosity informs all their experiences, including 'scientific' ones. It is hard to argue that the children's learning as part of this programme would in principle have been qualitatively different from learning about other aspects of the world around them. There appears to be a lack of logic in the contention (French, 2004, p.138) that science content in the early childhood curriculum is fascinating for young children, because they are biologically prepared to learn about the world around them. In contrast, we would argue that this preparedness would account for their general propensity to learn.

The children in our study were too young to have preconceptions about 'difficult' scientific concepts, although they had arrived at a point where ambivalent or negative parental and practitioner attitudes towards science might be transmitted. 'Normalising' science learning in the very early years therefore requires parental confidence, exactly what this study set out to encourage with the help of early childhood practitioners. The evidence gathered here strongly suggests that there is also a case for encouraging practitioner confidence in this area through enhanced initial training and ongoing support, which could take the form of good quality continuing professional development (CPD).

Given the nature of the evidence presented here, no generalisations can be made. All the same, the multiple perspectives reflected in the qualitative data we analysed led us to conclude that Nelson's 'experiential child' (2008, p.1) reflects the children in our study at least as well as Gopnik's 'intuitive scientist' (2009).

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Appendix

'Talking everyday science to very young children'

Outline contents 4 programme sessions

<u>Week 1: Forces</u>

Introduction to the talking everyday science sessions
Outdoor activity: Floating and sinking An introduction to the concepts of floating and sinking, with targeted questions for the children and parents. Children will have access to a range of water activities, water play with bubbles, funnels, and bottles. A range of everyday items to be tested to see if they float or sink variations to this will be if some objects take time to sink for example sponges. Possible prompts: **2-3 year olds:** *"What will happen when we put this object in the water?"* *"Is the object floating or sinking?"* **3-5 year olds:** *"What objects do you think will sink?"* *"What objects do you think will float?"* *"If we press the object will it sink faster?"*
Outdoor:: Cars, Balls and Ramps

Children to have free access to a range of balls, cars, and non-rolling items (wooden blocks?). Ramps to be created using wooden blocks and guttering. Children to investigate/consider the properties of items which roll, and to 'test' how quickly/far different items will roll. Opportunities for repetitive play and adaptation of items/ramps to adjust the length and speed that the items travel. Activity differentiated by children's choice of resources and adult prompts. Children to observe the play of their peers and adapt their own play accordingly. Parents and students to observe the choices of the children, the repetitive play, their observation of their peers and how the adapt activities according to the prompts or to their observations of their peers. Possible prompts: **2-3 year olds:** *" Ready, steady, roll, ooh all the way to the bottom….!"* *" Ready, steady, roll. Uh Oh, it got stuck in the middle!"* *" How can it go faster?"* *" How can it get to the bottom of the ramp!"* **3-5 year olds.** *" This car rolls right to the bottom of the ramp, I wonder why it does this?"* *" Oh dear, this wooden block gets stuck/falls to the bottom. I wonder why it doesn't roll like the car does?"* *" I can't make my car roll up the hill, it only wants to roll down! Can anyone help me?*
Discussion of possible activities that could be replicated at home. • Rolling cars and balls in the garden or down the stairs • Pushing floating items in the bath (blowing with straws?)
Vocabulary: Roll, top, bottom, ramp, pull, push, move, stop, predict, smooth, glide, quickly, slowly, round, pointed, edges, light, heavy, weight, float, sink, splash, big, small, soak, water, still, ripple, on the water, under the water, wood, metal, plastic, fabric, change, down, up, texture.

<u>**Week 2: Living things**</u>

Indoor : Exploration activity

Children to explore a range of different seeds and bulbs from plants, flowers and vegetables. Children to be encouraged to describe the colours, patterns and textures of the bulbs and seeds. Facilitator to explore what the children already know about how plants and flowers grow from seeds and bulbs. Drawing materials to be made available for children to draw /talk about their ideas. Facilitator to open the veg and fruit (e.g. peas, carrots with roots on, plants and flowers with roots attached. Parents and students to observe how the children explore the materials, and to record the comments that the children make in response to the questions/prompts.

Possible Prompts:

2-3 year olds:

"What do these feel like? What do they smell like? (facilitator to model feeling and smelling)

" Have you seen these before?"

" What's inside here? (peas-hold up to the light)"

3-5 year olds

" Where do you think I got these plants from? How did I get them? Have you seen these plants in your garden or in the park? What are these bits (roots)? I wonder what they are for?" This stem feels very strong, I wonder why it needs to be so strong?

"I want to have more flowers in my garden. What should I do with these (bulbs)?"

Outdoor : Exploration activity

Builder's tray with mealworms, leaves, real and artificial flowers, a variety of vegetables. Children to be encouraged to find the worms and explore their features. Facilitator, parents and students to be on hand to ensure that the children are handing the creatures appropriately. Children to explore the features of the worms, observe how they move and consider what they might eat. Children to be encouraged to compare the characteristics of the worms with human characteristics.

Possible prompts:

2-3 year olds:

" I wonder what this is? Can you see it moving? Where is it going?"

" I wonder what this is (snail?) Is it moving? I wonder which one is quicker?"

3-5 year olds: *As above + " Can you see any legs on the worm? I wonder how it moves then?"* *" What do you think they snail likes to eat? What about the worm? How do they find their food? Why do they need to eat? What does it feel like? I wonder why it has this shell on its back. Do you think it's heavy? I wonder what it would feel like to carry a shell on your back all day long!"*
Discussion of possible activities that could be replicated at home. • Planting seeds and bulbs • Opening peas • Exploring the inside of fruit and veg • Looking at fruit and veg in the supermarket • Looking at plants, flowers, worms and snails in the garden/park
Vocabulary Roots, seeds, bulbs, stem, leaves, petal, grow, water, soil, sun, names of different flowers and vegetables, pod, worm, snail, wriggle, crawl, slime, parts of the body, backbone/vertebrae?

Week 3: Materials

Indoor activity: Making play dough
Outdoor activity: Sand and cornflour play
Sand play Children to have access to dry sand and water, buckets, spades and watering cans. Children to explore mixing the sand and water together to fill and empty the buckets. Also to explore the movement of sand and water through the sand wheels and the water wheels. Children to be given opportunities to discuss the changing texture of the sand and water and how this has an effect on how the materials move and can be manipulated (e.g. 'catching water' *sprinkling* dry/wet sand/. Also to explore how adding water to sand effects the weight and strength of the sand (for making castles), and to consider what happens when the wet sand is left to dry out. Differentiated according to age of children by the nature and type of

interaction/questioning. Parents and students to observe the repetitive play, adaptation of activities and record the responses to the prompts/questions.

Cornflour play

The aim of the activity to observe the changes to materials when water, washing up liquid and food colouring is added to them.

Possible Prompts:

2-3 year olds:

" *Shall we pour the sand in here. Whee, look at the little wheel go round and round. I wonder why? (Repeat with water, over and again)*

" Who can fill this bucket all the way to the top?" Ready, steady…….!"

" What happens when we add some water to the sand…. Here goes!"

3-5 year olds

" I'm going to fill my bucket with all of this dry sand and make a sand castle. Oh no! It's all collapsed" I wonder why it won't stand up"

" I wonder what will happen if I add water to my sand. Who thinks my sand castle will stand up this time? Why do you think this?"

" Wow, my bucket is really heavy now (after mixing with water!). I wonder why. Which of these buckets is the heaviest?

" Ugh, this wet sand is all messy and gooey! Who knows where all the water has gone?! (when mixed with the sand)

" I wish my sand was dry again. How can I make it go back to being dry?"

Discussion of possible activities that could be replicated at home.

- Sand and water play
- Mud kitchen
- Baking and cooking
- Watching food in the microwave (scrambled eggs)
- Melting and freezing

Vocabulary:

Mix, water, sand, messy, gooey, combine, dissolve, evaporate, separate, heavy light, full, empty, strong, weak, collapse, unstable, stable, wet, dry

Week 4: Discussion with parents/carers about photo books

Indoor activity: Discussion with parents on the content of photo books. Researchers to complete end of project evaluation with parents. Students to collate observations, photographs and to complete their own evaluations of the research.

Table A. 'Talking everyday science' study research tools

Category of participant	Data gathered in advance	Data gathered during sessions	Data gathered after sessions	Data gathered after programme
Children (n=26)	nil	Intermittent audio recordings	nil	nil
Parents (n=19)	Semi-structured paper questionnaire (n=8)	Intermittent audio recordings	nil	Semi-structured paper questionnaire (n=5)
Centre practitioners (n=3)	Interview	Intermittent audio recordings	nil	Interview (n=4)
Students on research team (n=2)	Electronic semi-structured questionnaire	Intermittent audio recordings	Field notes	Electronic semi-structured questionnaire
Research team university staff members (3)	nil	Intermittent audio recordings	Field notes (n = 2)	nil