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A coteaching model for developing pre-service teachers' practice and confidence in teaching primary science through inquiry

Abstract

Teaching primary science through inquiry offers a number of benefits including developing pupils' science skills, progressing thinking skills and personal capabilities, and making science relevant to children's everyday experience. Ensuring that pre-service teachers (PSTs) are fully confident and competent in teaching inquiry-based science (IBS) however presents a number of challenges to initial teacher educators as teaching through inquiry calls for a high level of competence in classroom practice and an understanding of science concepts and theory. Opportunities to observe or teach IBS lessons during school experience are often limited thereby preventing PSTs acquiring personal experience of planning, teaching and evaluating inquiry-based lessons. This paper presents a model for coteaching where PSTs, initially, teach alongside peers before progressing to teaching with in-service teachers. Feedback from PSTs' written and oral evaluations indicate that the model is effective at developing their confidence and competence at each stage of their learning journey. We propose a sociocultural interpretation suggesting that coteaching addresses the cognitive and affective needs of PSTs and point to the valuable contribution which coteaching offers to all phases of science teacher education.

Key Words:

Coteaching: Inquiry-based science: Collaboration: Sociocultural: Practice.

The importance of inquiry within the science curriculum

Developing the scientific literacy of primary school pupils is more important than ever given the current Covid-19 global pandemic and the existential threat posed by the unfolding climate emergency. The rationale founded on the value of science education to both the individual and society has never been sounder in an age where sustainable lifestyle choices and compliance with public health advice are essential for the survival of one and all. Furthermore, living in the era of 'fake news' where evidence and the opinion of experts are often treated with suspicion, possessing a critical faculty and the ability to think scientifically is also important.

The study of science should therefore involve much more than simply the understanding of facts. The Royal Society (2010) proposes that teaching which prioritises the development of science and research skills increases scientific literacy and provides the stretch and challenge required to engage the scientists of the future. Furthermore, the Confederation of British Industry (CBI) recommend (2015) that science should be introduced at primary level in order to nurture pupils' interest from an early age. Harlen (2014) identifies how an inquiry based approach is naturally aligned to how children learn by enabling them to use their own ideas to make sense of new events and phenomena. The benefits of an inquiry-orientated approach to learning, brings benefits beyond science education. The curiosity and sense of purpose established by an aptly crafted inquiry activity provide the engagement and motivation for even the youngest of learners to begin to learn about learning (Harlen 2011). Within the rubric of inquiry it is the engagement with activities and tasks, which develops pupils' skills. Furthermore, these tasks provide a context and a personal experience on which to reflect on the goals of the activities, discuss progress and consider other's opinions and feedback. This metacognitive thinking allows for greater personal independence and learner autonomy. Inquiry-based science lessons also provide opportunities for the development of pupils' personal capabilities and thinking skills (Murphy, Bianchi, McCullagh, et al 2013).

Inquiry-based science within initial teacher education.

Reform of science education policies and the shift in curriculum towards more pupil-centred learning requires a change in classroom pedagogy. Qvortup (2008) noted in the first Global Education Forum that the quality of teachers' training is the most important determinant of the quality of education and thus for the efficiency and quality of the pupils' learning.

Osborne and Dillon's (2008) critical reflections on the state of science education in Europe recommended both a greater focus on extensive investigative work and hands-on experimentation, accompanied by high quality professional development for teachers. Wilson (2013) calls for carefully designed professional development programmes in the USA in response to the introduction of The Framework K-12 Science Education (National Research Council 2012).

Preparing pre-service teachers to plan, teach and evaluate their practice of inquiry-based science presents a number of challenges for initial teacher education (ITE). ITE tutors need to consider the wide range of pre-service teachers' personal experiences and perceptions of science teaching, which may possibly be at odds to the methods and practices exemplified within their ITE programme (Bachivan and Cobern 2016). These prior experiences shape PSTs' beliefs and conceptualisations of science education, and while they are formed at primary and secondary school, they can be reinforced throughout science methods courses during ITE (Pajares 1992). Many PSTs see the teacher as being in charge of classroom knowledge, resources and the learning environment (Thomas and Pedersen 2003), and associate science teaching more with teacher talk than pupil interaction (Goodlad 1984). This baseline about teaching can 'act as a filter or lens through which preservice teachers take action' (Thomas and Pedersen 2003, 319).

The current model for ITE where PSTs spend extended periods on school placement has not changed in over 100 years (Bacharach, Heck, and Dahlberg 2007). The premise is that the practice-related knowledge required to be a teacher is acquired during an extended period of placement with an experienced teacher who acts as a supervisor and mentor. A major problem with this arrangement is that during school placement PSTs may not have the opportunity to either observe science or actually teach it themselves (Blackmore, Howard, and Kington 2013; Lowry 2017). Santagata (2007) challenges the assumptions that exposure to practice constitutes a learning experience and that experience in the classroom 'melds' theory into practice. She cautions that the experience which pre-service teachers are exposed to may not represent best practice and may expose them to a limited repertoire of strategies used with an unrepresentative sample of pupils. This view is in line with Grossman and McDonald's (2008, 189) concerns that 'university-based teacher educators leave the development of pedagogical skill in the interactive aspects of teaching almost entirely to field experiences, the component of professional education over which we have the least control.' Murphy, Scantlebury and Milne (2015, 282) describe the traditional placement arrangement

as being akin to an apprenticeship where the PST learns 'on the job' and suggests that learning may be compromised by the existence of a power structure and hierarchy which places the PST in a subservient position to the cooperating teacher despite possibly having more up-to-date knowledge of science pedagogy.

Effective pedagogies for developing PSTs practice of inquiry

Within ITE 'methods' courses a wide range of different approaches have been reported to be effective at integrating theory and practice and preparing PSTs for their first experiences of teaching IBS. These have included microteaching (d'Alessio 2018; Bahcivan 2017), video supported 'cogenerative dialogue' (Siry & Martin 2014) and the use of collaborative partnership between schools and ITE institutions (Jones 2008). The common factors attributed to their reported success point to the merits of adopting a socio-cultural approach to learning which prioritises collaboration between learners, peer and tutor dialogue, and a supportive learning environment. Jones (2008, 68) reminds us that 'what PSTs learn is not only connected to how they learn and how they are assessed but it is also linked to satisfaction and enjoyment.' Therefore ITE programmes must consider the relationship between affect and cognitive growth. Vygotsky suggested that consciousness is composed of both intellect and affect and to separate them is a 'fundamental flaw' that separates thinking 'from all the fullness of real life, from the living motives, interests, and attractions of the thinking human' (Vygotsky 1934, cited in Wertsch, 1985, 189).

Coteaching is two or more teachers teaching together and sharing responsibility for the learning needs of students while at the same time learning from each other. The two participants can be both pre-service teachers, both in-service teachers or a pre-service teacher and an in-service teacher (Grenier 2011; Kerin and Murphy 2015). The involvement of pre-service teachers in coteaching has been shown to be an effective form of pedagogy in initial teacher education (Guise, Habib, Thiessen, et al 2017). The principal advantage of coteaching is that it values the knowledge, qualities and experience of both learners, allows for equal roles in the classroom and adopts a less hierarchical model for learning. In doing so it addresses many of the weaknesses within ITE programmes often arising from school placement such as learner anxiety, limited opportunities for extended periods of teaching and challenge of transferring theory into the enactment and evaluation of particular practice (Murphy 2016).

The study

The study was carried out with pre-service teachers from one of the two main ITE institutions in Northern Ireland. All participants were specialising in primary science as part on their four year undergraduate degree in primary education. The sample comprised three different year groups (Years 1-3) of undergraduate Bachelor of Education students specialising in Primary Science. Data from an additional Year 3 group who cotaught the previous year is also included. The groups are labelled according to their year group with the two separate groups of Year 3 students labelled 3A and 3B. Each year group experienced different coteaching arrangements as shown in Table 1. The study traces the progression from peers coteaching small groups of pupils on-campus in Year 1, to Year 3B PSTs coteaching alongside science subject leaders during the course of a funded curriculum development project.

Year Group and (Number of pre-service teachers)	**Who is Coteaching?**	**Where do they teach?**	**Aims of coteaching**
Year 1 (N=10)	Groups of 3 to 4 pre-service teachers	ITE Campus	Development of PST's understanding and practice of play and early years science
Year 2 (N=13)	Pre-service Teacher: Pre-service teacher	Partner School 1	Develop of PST's understanding and practice of inquiry science
Year 3A (N=7)	Pre-service Teacher: In-service teacher	Partner School 2	Develop PST's practice of science inquiry and audit inquiry skills throughout a single school.
Year 3B (N=6)	Pre-service Teacher: Subject Leader	Six partner schools	Develop practice of PST's and create curriculum support resource for all schools.

Table 1: Summary of the study details.

Background and Context.

Primary science in NI schools

Within the Northern Ireland Primary Curriculum, Science and Technology is included alongside history and geography in one of seven 'Areas of Learning' called 'The World Around Us.' The curriculum content is organised around four 'strands' which allow for a topic-based approach suitable for science, history and geography. The curriculum also states that 'by doing science in schools, pupils will be able to develop behaviour and skills that reflect those of real scientists. The emphasis will be on knowledge acquisition as a result of the process of questioning, observing, investigating, identifying patterns, explaining and initiating enquiry,' (CCEA 2017 p4). However there are concerns about the profile of science and technology within the primary school curriculum. The Education and Training Inspectorate's survey (2015) of science and technology provision within the 'World Around Us' considered that Science and Technology was underdeveloped in 54% of schools sampled and that 'provision focussed on low-level factual learning within isolated topics and lacked purposeful investigative experiences for children' (p.37). The concerns about the state of primary science in primary schools are also shared across other regions of the UK (Alexander,2010; CBI 2015: Parry et al 2019.) A recent survey (Lowry, 2017) of final year undergraduate student teachers within an ITE institution in Northern Ireland reported that 41% had taught less than 3 science lessons throughout the four years of their B.Ed degree and 11% of students had never taught any science. A reduction in the amount of science taught in primary schools will therefore restrict PSTs first-hand experience during placement. This study sought to explore if and how coteaching can be used to develop the inquiry practice of pre-service teachers across each stage of their ITE programme.

Details of Coteaching Arrangements

The study was conducted over a single academic year and involved three cohorts of PSTs (Year 1, Year 2 and Year 3A) and included data collected from a Year 3 cohort (Year 3B) who had cotaught the previous year.

Year 1PSTs

Ten pre-service teachers, collaborated, in groups of three or four, to plan, deliver, and evaluate a playful science inquiry session to visiting 5-6 year-old pupils in the Early Years Centre of the College campus. Each group's workshop lasted between 1-1.5 hours and involved a class of approximately 30 Foundation Stage children. In preparation for these workshops, student teachers engaged in workshops and seminars exploring issues such as play as pedagogy for inquiry, science in the early years, and playful interactions. Students selected the theme for the session, and worked collaboratively to plan between five and six play stations that would develop Science knowledge and skills.

Year 2 PSTs

Thirteen pre-service teachers worked as five pairs and a group of three to plan, teach and evaluate a series of six lessons in a partner primary school. Lessons lasted between 30 and 45 minutes and were taught over six successive weeks. Prior to coteaching, the planning phase involved a series of seminars on theory and a number of workshops based on popular primary science inquiry activities. Each group was provided with details of the class they would be working with and the topic. Draft lesson plans and ideas for inquiry tasks were approved by the tutors and agreed with cooperating teachers.

Year 3A PSTs

By their third year pre-service teachers had already experienced the coteaching described above for Years 1 and 2. In Year 3 both groups cotaught with in-service teachers but in two different arrangements. PSTs in Group 3A were paired with in-service teachers in one partner primary school with one coteaching pair placed in each of the seven year groups of pupils in the school. A similar programme as described for Year 2 was followed, with a campus-based planning and preparation phase, a coteaching phase, and a concluding feedback and evaluation seminar in College. During the planning phase an after-school workshop held at the school included sessions on inquiry-based science and established a protocol for coteaching, as well as allowing both partners to become acquainted. Though tasks were to be shared between both partners, the pre-service teachers were charged with the overall responsibility for the lessons. While all lessons included opportunities for pupils to develop a number of inquiry skills, each lesson identified one specific skill as its focus.

Year 3B

This coteaching arrangement was part of the curriculum development project 'Teacher Assessment in Primary Science for Northern Ireland' (TAPS-NI) funded by the Primary Science Teaching Trust (PSTT 2019) and carried out in collaboration with another ITE institution in the UK. Prior to this study, the TAPS-NI project had involved a cluster of six science subject leaders from different primary schools working together to create science inquiry tasks suitable for the assessment of inquiry skills. The aim was to use coteaching between the six subject leaders and six Year 3B pre-service teachers to evaluate and develop the activities produced to date and to create new ones over the course of six lessons. Funding for the project allowed for a whole day planning seminar before coteaching and an evaluation/ resource production workshop at the end.

Methodology

Research Question and Design

The research was guided by the question, 'can coteaching support the development of PSTs' practice of IBS as they progress through an ITE programme?' The aim of the research was to access and explore the views and experiences of pre-service teachers at each stage of a progressive model for coteaching. Therefore an interpretivist paradigm was adopted in order to 'best understand the subjective world of human experience' (Cohen, Manion and Morrison 2011, 17). The study is best described as a case study, where the case was an investigation of pre-service pre-service teachers within an ITE institution.

Participants

Consent to participate in the data collection activities was obtained from all participants. The research was carried out within the ethical protocols of the University College and ensured that participants were free to opt out at any stage during the data collection activities, their identity remained anonymous, and the research activity had no bearing on the module assessment rubric.

Data Collection

Two sources of data were used. The first took the form of the participants' written responses to the question 'Do you feel that coteaching was helpful in developing your practice?' The account, written immediately after coteaching, required participants to provide examples of experiences to support their response and to consider if and how the coteaching experience would support them during forthcoming school placement. The second data source was the transcript of a short 10 minute presentation and short follow-up discussion with peers and tutors, given by each pre-service teacher on the topic 'my experience of coteaching inquiry science in (Name of Primary School).' The presentations were video recorded and the contents transcribed. The follow-up questions allowed the researchers to explore any themes emerging from the completed transcripts and provided a 'chain of evidence' (Yin, 2009: 41) to enhance the reliability of the findings.

Data Analysis and validity

The written accounts were independently analysed by each researcher. Repeated readings of the accounts allowed for recurring themes to be identified. Each theme was then coded according to how it related to the PSTs activity or emotion. In this way we sought to explore both the practice and perceptions regarding teaching IBS. Comparison showed a high level of consistency between how each theme had been coded. Differences in interpretation were discussed and resolved before a final tally was made.

Findings

Year 1

All ten of the pre-service teachers reported that coteaching had developed their ability to teach science through inquiry and that it had been a valuable and an enjoyable experience. The principal advantages of this coteaching arrangement were that these novices were assisting and supporting each other in each aspect of practice and that they had the opportunity to work with smaller groups of pupils. Close collaboration with peers helped them to learn *how to teach* and richer interactions with pupils enabled them to learn *about teaching.* Figure 1. shows the themes and how frequently they were cited.

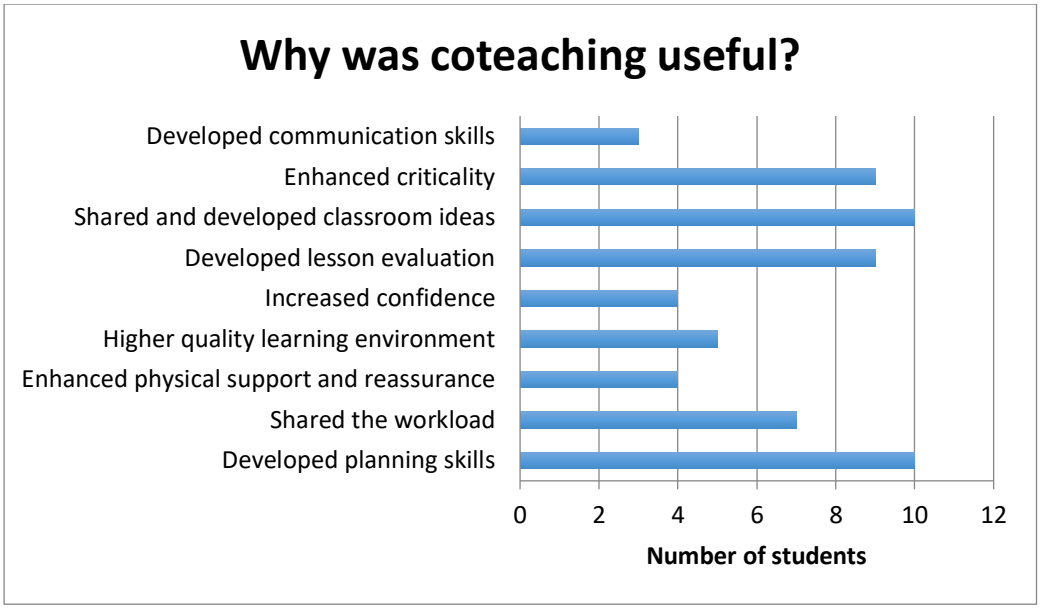

Figure 1: The advantages of coteaching as identified by Year 1 PSTs.

Learning how to teach

The aspects of practice most frequently cited were planning and evaluation. A collaborative approach to lesson planning was considered very helpful, particularly as this was their first experience of it.

"Coplanning also sped the process of planning up and it gave us a better basis rather than starting from scratch on our own, which was extremely helpful particularly as our science workshop was the first plan we had made that we would carry out." PST14 (Student '4' in the Year 1 cohort)

Planning together provided access to more ideas for learning activities and allowed prior experience or expertise to inform practice.

"Coplanning allowed ideas and thoughts to be discussed and edited to produce a complete plan that was detailed and structured. Furthermore, group planning allowed the workload to be shared and completed by different members. As we all had a section to work on, it meant that the plan, when put together, was comprehensive and explicit in what we wanted to do." PST17 (Student '7' in the Year 1 cohort).

The lessons produced by co-planning were described as being more: - *rigorous,- explicit – improved- developed,* and the process as - *transformative- more appropriate-enriched- more engaging- more interesting.*

Accessing the views of other PSTs during co-evaluation was also considered useful.

"Coevaluation was crucial as it offered an outside perspective…Coevaluating helped to identify why children might not have wanted to be involved and share ideas on how they could be encouraged to be included more." PST16

Learning about teaching

Coteaching made for a closer study of the relationship between teaching and learning by enabling pre-service teachers to work more closely with individuals or small groups of pupils and providing a shared experience of the teacher-pupil interaction.

The coteaching approach gave me an opportunity to experience teaching children in small groups. It allowed me to focus my attention on how to create a stimulating and engaging playstations (sic) for children, and how to use language to help improve children's understanding. This will then allow me to focus on whole-class teaching in the future due to developing these skills with smaller groups currently." PST110

Year 2

The data for Year 2 (Figure 2) also highlighted the benefits of co-planning and co-evaluating

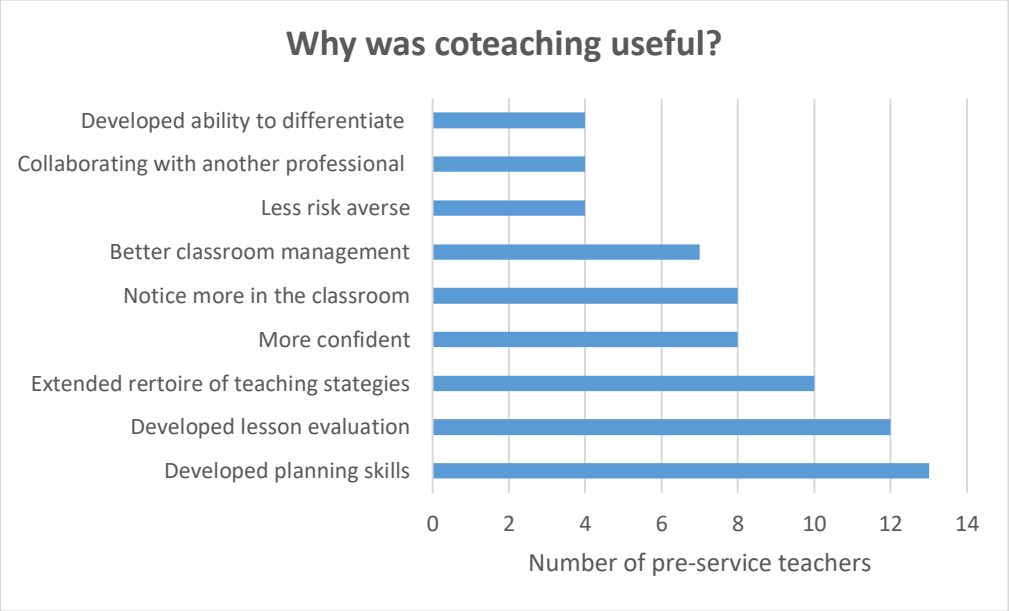

Figure 2. The advantages of coteaching identified by Year 2 pre-service teachers.

The closer collaboration required for working as a pair rather than a group resulted in more specific references to the practice of a partner. The following comment describes how progress in planning went beyond exchanging or critiquing ideas.

I found it really beneficial to observe how may partner firstly planned her lessons. I have learnt from her to be more particular in presenting my lesson plans in a clear format which makes it accessible and easy to read, which has been of great benefit when I have had to look at it quickly perhaps during class time to know where to take the lesson. PST23 (Student '3' in the Year 2 cohort)

The benefits arising from the need for dialogue between coteachers was frequently referenced. Proposing and rationalizing their plans moved participants further in their thinking than if they had been teaching alone.

Coteaching has made my lessons better organised. When planning with my partner, I have had to have a clear plan of the things which I would ask and explain. This has been helpful as often I can perhaps only have a vague idea of what I will say before lessons begin, but here I have to be specific about what I will say in order to inform my partner about what I will say at each stage of the lesson. PST25

The shared experience and dialogue allowed for confirmation and validation of individual opinions.

It was helpful to discuss and support each other's opinions about which pupils needed additional support. This helped me to develop as I was reassured in my ability to pinpoint the individual needs of pupils in the classroom. PST22

The supportive nature of coteaching was also reported.

It was reassuring to get positive feedback, as it is sometimes hard on your own to pick on out what went well. PST213

There were also many benefits attributed to teaching side-by-side, such as *'seeing other's practice up close,'* and examples of where they complimented or modified their partners teaching during a lesson.

If he thought the class would go off on a tangent he was swift to add in a more direct question to keep them focussed- this was really valuable and I have improved my use of questioning. PST27

Year 3A

Coteaching with an in-service teacher was highly valued by all seven pre-service teachers whose feedback reflected the different learning context. A smaller proportion identified an increase in their planning or evaluating skills than was the case for Years 1 and 2. Often finding time to co-plan with the in-service teacher was difficult. However there was a stronger focus on developing their classroom practice and acquiring new and effective teaching strategies. The situational knowledge and experience of the in-service teacher made classroom and behaviour management less of a concern than had been the case in Year 2. Collaborating with a 'real teacher' was considered to provide an insight into higher forms of practice. As PST3A4 put it, '*the teacher had really great control of the class and I could see just how he was doing it.'* The higher status of the in-service teacher also had a motivating effect as indicated by the comment, *'my teacher was really organised which meant I felt I had to be much better prepared- like a real teacher*!'

This shift of focus from classroom management allowed the pre-service teachers to focus other things. There were more references to science inquiry skills than in the feedback from Years 1 and 2.

The coteaching allowed me to work with smaller groups of pupils, particularly the ones who weren't getting the science skill. I could really listen to their ideas and talk them through it. Normally I'd never see this and have to keep moving on. PST3A6

Year 3B

This experience of coteaching with expert science leaders was highly valued by all six participants.

It was really great to work with the science leaders planning lessons and interesting to see them put together their schemes of work and see where they could fit in each skill. She could take my ideas and change them to make it work with her class. PST3B2

The project's focus on the assessment of inquiry skills was considered to provide many opportunities for experiencing assessment strategies.

I have found assessing their written work ok but when it is skills they should be doing during the class it is much harder. I learned how to plan for this and use smaller groups at a time. PST3B4

The insight into assessment of skills was further enhanced by the pre-service teachers' involvement in the evaluation seminar and the group discussion.

*It was useful to discuss the lessons and look at the samples and photos of work and look for the criteria. I really learned how to do this and that it is ok not to be always sure.*PST3B1

Working alongside science enthusiasts had quite a motivating effect on several pre-service teachers.

She was so enthusiastic about science and was always trying to get the children thinking- so different to teachers on placement who had no interest in science. She loved talking about possible activities and saying we should try this. PST3B2

Discussion

Our findings indicate that coteaching is effective at supporting PSTs in each aspect of practice (Figure 3) and also at each stage of their development. The discussion will consider why coteaching is effective and how it can progress pre-service teachers' practice of IBS.

Co-construction of knowledge

Many of the characteristics of constructivism as described by Staver (1998) are evident within the practice of coteaching, namely that the individual and community build knowledge which is practical and is adaptive and can be developed via social interactions. The pre-service teachers' feedback on coteaching is consistent with a sociocultural conceptualisation of learning as a collaborative, developmental, and purposeful human activity. Vygotsky (2004, 83) placed action at the centre of development, stating that 'psychological functions emerge out of social, collective activity.' When pre-service teachers coteach they are adopting what Stetsenko (2008) describes as a 'transformative activist stance' with respect to learning to teach. Based on the work of Vygotsky, Piaget and Dewey, Stetsenko (2008,478) stresses the centrality of collaborative activity within the process of transformation. Coteaching enables the learner to overcome what she describes as 'the spectator stance, through the realisation that the only access people have to reality is through active engagement with and participation in it, rather than simply 'being' in the world.' Vygotsky (2004) considered social-cultural influences to be fundamental in the formation and development of human thinking and that for the individual, the social origin of higher levels

of thinking lay with socially shared cognition between people (inter-psychological) and then with the individual themselves (intra-psychological). He used the term internalisation for this process by which social becomes psychological, and considered language to play a key role.' It is this dialogue between coteachers which is at the heart of the learning. The coteaching experience is crucial in order for both parties to establish what Smidt (2009, 127) refers to as 'intersubjectivity'- 'the shared meaning that people construct through their interactions with one another as they use cultural tools to interpret the meanings of their social or cultural or intellectual lives.'

Coteaching and the Zone of Proximal Development

Vygotsky proposed that learning is most valuable when it takes place just ahead of development and that it requires a form of scaffolding or support to mediate this journey across the 'zone of proximal devlopment' (ZPD). Warford (2011, 252) describes the ZPD as 'the distance between what a learner is able to do and a proximal level that they might attain through the guidance of an expert-other.' Murphy and Scantlebury (2011) however point out that within educational contexts there is too strong an emphasis on the 'expert' nature of 'the other' and not enough consideration given to the importance of peer co-constitution of knowledge. In coteaching between peers, particularly when they have little or no classroom experience, the activity more resembles a joint interpretation of practice rather than an expert-novice scenario.

Within the ZPD each partner serves as an additional source of knowledge and experience as well as a stimulus for dialogue and critical thought. In addition to facilitating the cognitive activities of observing, comparing, challenging ideas, testing, and questioning, the ZPD attends to the emotional needs of the participants. The moral support of peers and feelings of collegiality and empathy with each other seemed to sustain and encourage the pre-service teachers.

Progression of coteaching

We propose a model for progressing coteaching over the course of an ITE programme. In Year 1, coteaching serves as a means to reduce the complexity of solo classroom teaching. This is achieved by small groups of pre-service teachers teaching groups of pupils brought onto campus in a prepared classroom. In addition to reducing the complexity of the classroom, coteaching enables novices to learn in low risk settings where they have the freedom to take risks and try out approaches in a secure setting. Whilst this decomposition of

practice may be perceived to be reducing the authenticity, it does serve a pedagogical purpose. It is the role of the facilitator to take full advantage of this opportunity to extend and develop pre-service teachers' thinking and guide their actions through feedback and discussion. Thinking about the complexity of teaching in an incremental scale is useful in presenting teacher education as a continuum comprised of increasingly authentic approximations of practice (Grossman and McDonald 2008).

For Year 2 the shift from campus to classroom brings the additional task of planning to teach a whole class of pupils in a new environment. Unlike the case in Year 1, the topics were chosen by the school, which further challenged the subject knowledge, creativity and planning skills of the coteachers. Teaching in pairs requires close observation of the other whilst still remaining in the action. Coteaching meets all the requirements for effective 'modelling' (Thom 2018) as the competence gap between observer and modeler is not too great with opportunities for the observer to try and enact what has just been observed.

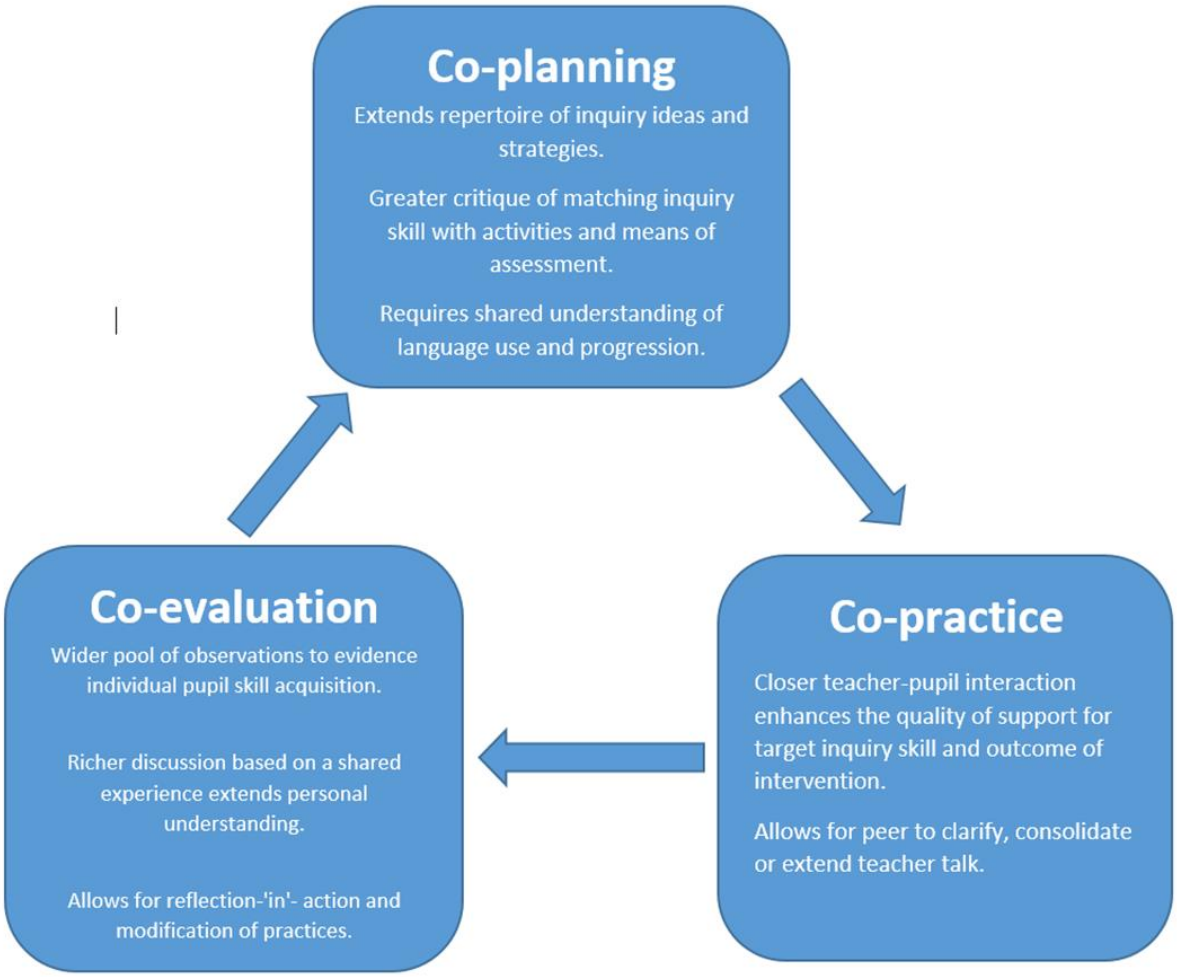

Figure 3. How coteaching supports PSTs in each aspect of teaching science through inquiry

In Year 3 all the PSTs benefitted from the additional experience and situated knowledge of the in-service teacher as it enabled them to engage with more nuanced aspects of practice. Here the benefits of coteaching with a more knowledgeable other went beyond experiencing and assimilating the 'best practice' on display. Working within this secure and stable environment empowered the pre-service teachers to focus more closely on pupil learning and explore the teacher-learner dynamic in greater depth. Both Year 3 groups reported more on how coteaching had developed their practice of IBS. There was evidence (Table 2) of PSTs developing their teaching and assessing each of the seven science inquiry skills specified within the Northern Ireland Primary Curriculum. (CCEA 2017).

Inquiry Skill	**How did coteaching develop PSTs teaching of science inquiry skills?**
Observation	*"Smaller groups meant that I could spend more time directing pupils to what they need to look out for."*PST 3A4
Questioning	*"I had time to listen to their ideas and try to could get them to think more about what they wanted to find out. This takes time but I could see it working- normally I'd have moved on to another group."* PST3A1
Planning	*" My coteacher would help out a weak group by showing them the different materials and asking how they might use this to find out about keeping warm- I*

	was able to make sense of their ideas and help them form a plan. This 'double act' really helped and encouraged them." PST3B2
Predicting	*"I was able to introduce specific vocabulary such as 'observe' and 'predict' to P2 children (6 year olds) and their ability to both understand the concept of the word and use it in their vocabulary amazed me. This consolidated my belief that we need to introduce these words to children from an early age.* PST3A5
Doing	*"We took a group each and could keep an eye on them measuring out the water and making sure everyone at the table had a go at reading the measuring cylinder."*PST3B4
Evaluating	*" In front of the class the teacher and I would mention examples of reliable results and things that needed to be checked- this would indirectly support pupils." to review and evaluate their work. These 'conversations' were great for prompting them to self-evaluate and develop their work."* PST3A6
Recording and Communicating	*" I had time to help them take photos with the iPad and to record their ideas- when the teacher was taking the plenary I could get them up on the white board- they loved seeing each other's photos and videos which got them talking and it also meant that all pupils could see a full set of results."*PST3B3

Table 2. How coteaching helped PSTs in their teaching of science inquiry skills.

Year 3B pre-service teachers reported benefitting greatly from actively contributing to a funded curriculum development project. They valued working alongside science subject leaders and attending the project planning and resource production days. These experiences, rare for undergraduates, provided an insight into the skills and disposition required of an effective subject leader. Lawrence (2011) points out that new subject leaders may have had few opportunities during initial teacher training or early career to observe and learn from good practice in primary science teaching and leadership and cautions that subject leadership training can be limited to generic courses which do not address the subject and pedagogical knowledge needed to support colleagues.

Conclusion and implications

We have highlighted the importance of adopting an inquiry-based approach to teaching science in primary school and established the challenges faced by teacher educators as they seek ways to develop this aspect of PST's practice. This study has described a model for coteaching IBS which addresses the cognitive and affective needs of PSTs as they progress through their ITE programme and develops their competence and confidence in teaching science through inquiry. Our progressive model of coteaching firstly facilitates peer collaboration and support to help develop novices' teaching skills and allow them to come to terms with the professional routines and practices required of a teacher, particularly planning and evaluation. Coteaching with in-service teachers provides a more detailed examination of classroom practice and enables PSTs to benefit from the situated local knowledge of the experienced teacher as they adapt their theoretical understanding of science inquiry to the real context of the particular classroom and science topic. The opportunity to coteach with science subject leaders and to create new forms of practice further extends PSTs expertise and nurtures professional agency and a more critical and reflective mind set.

Whilst the focus of this paper has been on ITE our findings also point to the value of coteaching as a method for developing the practice of in-service teachers and for the creation of new forms of pedagogy, as well as new resources. The low profile of science and IBS within primary schools makes for a less than ideal environment in which to prepare the teachers of the future and is likely to produce newly qualified teachers who are unskilled in this form of teaching and disinclined to adapt this approach or espouse an inquiry culture around the school. Figure 4 shows how this can result in a cycle of teacher education where

current practices are merely replicated and consolidated by the next generation of practitioners. In contrast, coteaching offers the means to both grow the practice of pre-and in-service teachers and promote a culture of professional growth. The synergy resulting from two teachers working together can reach further and wider than the classroom practice of the two individuals and thus elevate the science practice of the whole school and science education community. This in turn will provide an even richer learning environment in which future cohorts of PSTs can continue to further explore and refine practice. Just as we learn through teaching, we can grow through coteaching.

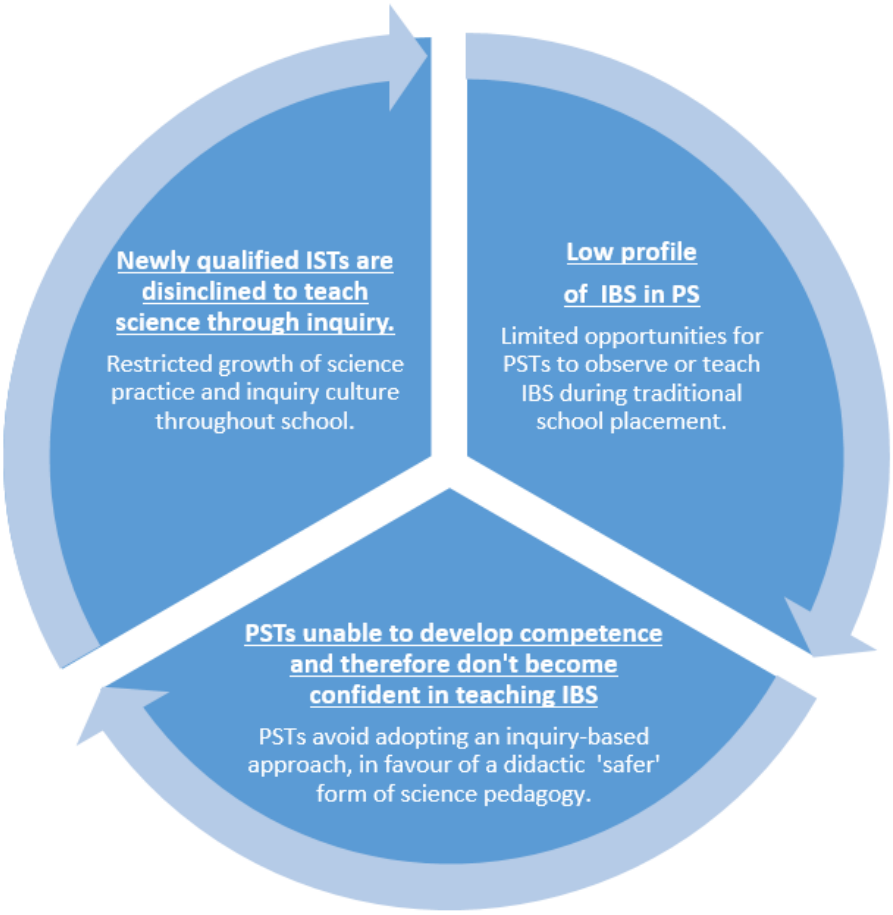

Figure 4. Sole reliance on the placement model of school experience may result in a cycle of decline for IBS.

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