Asking the right questions: An exploration into the introduction of co-coaching within initial teacher science education

Karen Blackmore

School of Education, University of Worcester, Henwick Grove, Worcester, U.K.

Abstract

Purpose

This study aimed to explore whether aspects of co-coaching could support primary science teacher education in a University-School initial teacher education partnership programme in England.

Design

A mixed methodological approach was taken, comprising of student teachers responding to a coaching questionnaire blended with a qualitative exploration of audio recorded student teacher co-coaching conversations. Informal student teacher discussion groups were used as a means to discern their attitudes and beliefs pertaining to co-coaching within taught university sessions.

Findings

Analysis and subsequent integration of data showed that many aspects of co-coaching supported student teacher pedagogical knowledge acquisition and professional development. Additionally, questionnaire responses and small-group discussions revealed that student teachers developed positive attitudes to this mode of learning.

Originality/Value

This study evaluates the innovative use of co-coaching techniques during primary teacher science education and the outcomes have clear implications for the design of initial teacher education programmes in England and potentially further afield.

Key words: co-coaching, science teacher education, professional development, Science Technology Engineering Mathematics (STEM)

Introduction

The focus of this work was derived from the researcher's own reflexive practice in initial teacher education (ITE), where she taught on the three-year Bachelor of Arts in Primary Education with Qualified Teacher Status (QTS) programme. As a science learner of some 50 years and teacher educator for over a decade, she had experienced a wide range of scientific teaching and learning, which prompted her to question what aspects of education facilitate the preparation of exceptional primary science teachers (teachers of pupils aged 5-11 years old). Since a dialogic approach had recently been shown to have a positive impact on ITE (Jones et al., 2018; Simpson, 2016), she wished to explore whether coaching had the capacity to support the professional development of student teachers during science ITE.

The complexity of primary teacher education within ITE programmes

At the culmination of ITE programmes, newly qualified primary teachers in England must be confident and competent to deliver effective lessons across a broad curriculum, including the three core subjects – English, mathematics and science – and the foundation subjects, for example, history, geography and art (Department for Education [DfE], 2013). This is a challenging remit given that during their education, student teachers must concomitantly refresh their own subject knowledge (SK) and develop a deep understanding of how children learn. They are also required to acquire a knowledge of how best to organize their SK from a teaching perspective in order to help learners understand specific science concepts. This may take the form of an appreciation of the most effective illustrations of certain subject matter or an awareness of common misconceptions of key scientific ideas. This combination of SK and pedagogy is termed pedagogic content knowledge (PCK) and is accepted as a prominent prerequisite for effective teaching (Shulman, 1986). Student teachers must also learn to operate, sometimes within a single week, in different educational settings (university and schools), simultaneously performing as effective teachers and learners.

With respect to the science requirements of the National Curriculum (DfE, 2013), it has been argued that there are certain components within primary science that require particular pedagogical support (Harlen, 2001, 2011; Harlen and Qualter, 2018). For example, during their scientific study, children are required to observe, make measurements, organize and analyse data from an early age. These skills are not intrinsic to many children; rather, they need to be learned (Zimmerman, 2005). Additionally, often in scientific enquiry, children are required to access higher order thinking, which can be challenging to promote in young learners (Cole and McGuire, 2012). To effectively support and scaffold scientific learning for children, newly qualified teachers need to be confident that they are in possession of strong SK and that they can effectively communicate that knowledge to children (Harlen and Qualter, 2014).

What might be the benefits of coaching for student teachers' professional development?

A review of the literature revealed that the benefits of coaching experienced teaching staff in schools is well documented (Hampton *et al.,* 2004; Thomas and Smith, 2009; Tolhurt, 2010; Lofthouse *et al.,* 2010). In terms of student teacher development, Sorenson (2012) highlights the potential of coaching during ITE as a means of "bringing theory and practice closer together" (p. 204). However, despite the reporting of studies in the United States (US) (Podsen and Denmark, 2006) and Europe (Anghel and Voica, 2013) into the benefits of coaching, there is little evidence that it is a prevalent component of teacher ITE in England (Salter, 2015).

Cox (2012) examines the mechanisms by which coaching could be used as a conduit for teacher professional learning and argues that it is an ideal tool, since it allows learning from one area to be reflected on and repositioned for use in another. This rationale builds on the work of Stewart and Palmer (2009, p. 33), who defined the term "coaching transfer" as "the sustained application of knowledge, skills, attitudes and other qualities gained in the workplace". This type of process is a prerequisite for high-quality teacher education and echoes early work by Joyce and Showers (1980) who argue that in order for teachers to deploy new skills and knowledge effectively and embed them within an active teaching repertoire, they need to be supported within a positive mentoring or coaching environment.

The work of Royer *et al.* (2005) is illustrative of an underlying process by which teachers may find this type of coaching transfer invaluable during their education. They define the process as being facilitative because it allows "information learned at a particular point in time to influence performance at a later position in time" (p. 83). This is particularly pertinent given that student teachers have to perform according to rigorous professional standards across both temporal and physical divides. Coaching has the added benefit of improving the ability of an individual to improvise during times of particular challenge (Cox, 2012), since coaching conversations afford the opportunity to hypothesize and trial various problem-solving scenarios (Averill, 2016). Hence, previous conversations allow teachers to improvise with confidence during unexpected classroom occurrences, akin to the process of reflection-in-action as formulated by Schön (1983). In this way, coaching could act as a catalyst for the initiation of deep reflection upon classroom practice and enable student teachers to "make new sense of the situations of uncertainty or uniqueness" (Schön, 1983, p. 61). Indeed, successful student and newly qualified teachers often display the ability to be flexible and use their intuition to improvise in times of challenge during their early careers (Borko and Livingston, 1989).

What elements of co-coaching might be particularly suited to primary undergraduate ITE provision?

The synthesis of perspectives as to what constitutes coaching (Law, 2013) is instructive when considering if coaching could be employed within ITE. He highlights the work of Downey (1999) who defines coaching for performance and development whilst foregrounding the role of conversation (Parsloe, 1995) to encourage personal responsibility and self-directed learning (Law, 2013).

Historical studies from the United Kingdom (UK) (Goethals *et al.,* 1999; Topping, 1996) suggest that there could be potential for using coaching to support learning within undergraduate provision. Additionally, a collaboration between Rice University and the Association for Coaching (AC) (UK) revealed that the majority of students (66%) involved in a 12-week coaching initiative believed it had befitted their learning (Bresser, cited in Law, 2013). The undergraduate Leadership Studies students in the Rice University study also reported that they found coaching sessions of added value and were different from other educational opportunities afforded them. They felt the coaching interactions were advantageous because they offered personalized support and prompted improved reflection upon learning. Since these students were at a similar stage of academic development as student teachers on Primary Education with QTS courses, and their courses shared common values and interests, this further supports the argument that coaching could have a role within undergraduate ITE.

From coaching to co-coaching

Co-coaching opens up the option of bidirectional movement of learning between individuals and is perhaps an extension of the acknowledgement (according to Healy, 2005) that there is a degree of reciprocity between teaching and learning. Specifically, with respect to co-coaching, the Centre for the Use of Research and Evidence in Education (CUREE, 2005) state that co-coaches show well-developed interpersonal skills and are able to relate sensitively to each other. They are also adept at sharing and understanding each other's goals and drawing on specific evidence to help each other make sense of issues (Jewett and MacPhee, 2012). In the US, this approach appears to be synonymous with peer coaching, as defined by Parker *et al.* (2008, p. 489): "a dyadic relationship between two individuals of equal status that has as the primary purpose to support the personal and professional development of both parties".

Peer coaching is sometimes advocated as an efficient, low-cost alternative to traditional one-to-one coaching programmes for professional development. However, later literature (Lofthouse and Leat, 2013) emphasizes that it is not always straightforward and relies heavily on conducive situational, contextual and relational factors being present. Reciprocal peer coaching (where pairs of teachers coach each other in turn) of experienced teachers has been advocated as a means of affording teaching colleagues opportunities to engage in enhanced experimentation, reflection and problem solving as a means of shared professional development (Zwart *et al*., 2007).

Why might co-coaching be an effective conduit for science-specific student teacher professional development?

With specific reference to STEM learning and teaching, Ryan (2003) illustrates the processes student primary science teachers go through during their transition to qualified teachers. He describes how student teachers develop an initial conception of how they want to teach science, followed by a phase of refinement and interpretation within classroom complexity. Student teachers often have difficulties in synthesizing information concerning what they have experienced in school as teachers with appropriate theoretical underpinning. Ryan advocates in-depth discussion with student teachers at key points to maximize assimilation of their evolving pedagogy and development of PCK. This approach is supported by the work of Bochman (2016) who found that early career teachers derived benefits in terms of developing their pedagogy from a series of structured conversations with each other, prior to teaching STEM subjects.

Additionally, an Australian study focusing on the use of peer coaching to support primary mathematics teacher development revealed co-coaching helped them to think critically about their choices as a teacher and reflect effectively (Averill *et al.*, 2016).

During ITE, it would seem ideal for student teachers to be given the opportunity to examine their practice in order to seize new teaching opportunities to plan and implement meaningful science experiences for their learners (Eick and Reed, 2002). It is also generally accepted that unless primary teachers see an aspect of their identity as teachers of science, they will not teach science as effectively (Luehmann, 2007). What is required, therefore, is appropriate science-specific scaffolding that is supportive enough to be enabling but flexible enough to allow for personal and professional growth. One way of achieving this challenging remit may be to implement co-coaching strategies where student teachers can learn from each other under the guidance of an experienced teacher educator so that they feel supported but not overly directed. Downey's (1999) idea of a coaching continuum could be an interesting refinement of this approach since he recognized that during coaching conversations, there may be occasions where the coach suggests possible direction, whilst at other times, the coach may say very little and rely on the coachee's knowledge and skills to suggest possible solutions. Downey advocates encouraging self-discovery by moving along the directive/non-directive continuum during some of the subsequent coaching interactions. In this way, the coachee is empowered to postulate and make concrete plans to address identified issues. An added advantage to this approach is evidenced from industry and suggests that when workers come up with their own solutions to problems, they are significantly more likely to follow through with an action rather than fail to act (Wall, 2016).

Critics of this approach might argue that primary student teachers already have an extensive learning remit, and asking them to acquire co-coaching skills is a step too far. The counter argument to this is that any process that supports learning efficiency and encourages primary student teachers to refine knowledge could be an important developmental tool.

Research aims

Given the arguments above, the researcher endeavoured to understand if co-coaching techniques were an appropriate tool that could be used during undergraduate ITE to enhance learning. In order to address the research objective, it was reduced to a main research question (mRQ) and a sub question (sRQ) as follows:

> mRQ: *Are there aspects of co-coaching techniques which can be used to support the acquisition of science subject knowledge, pedagogy and pedagogical content knowledge for student teachers?*
>
> *sRQ: What attitudes and beliefs do primary student teachers have about the use of co-coaching techniques to support their education as primary science teachers?*

For both research questions, co-coaching was defined according to CUREE (2005, p. 3) as "a structured, sustained process between two or more professional learners to enable them to embed new knowledge and skills from specialist sources in day-to-day practice".

Methodology

Philosophical stance

Since the study required, in part, the interpretation of attitudes and feelings of student teachers towards coaching techniques, an interpretivist stance was adopted. A mixed methodological approach was undertaken according to the perspective of Creswell and Plano Clark (2011) who argue that such methodologies offer synergy by which the deficiencies of quantitative methods can be abrogated by the addition of qualitative techniques. To reduce the risk of researcher bias, a protocol was developed of strictly adhering to a triangulation strategy, where data was examined from questionnaires, transcriptions of short co-coaching conversations and memo making during informal small-group discussions.

The sample

The participants were student teachers enrolled on a compulsory second-year module focusing on primary science pedagogy as part of a three-year Bachelor of Arts Primary

Education with QTS programme in a single University-school partnership scheme in the West Midlands region of England. Participants were eligible for inclusion if they had successfully completed all the prerequisite Level 4 modules and passed their first professional teaching experience in school. A convenience sample, which comprised student teachers belonging to two of the five teaching groups within the second-year cohort (50 student teachers of 125), was approached to be involved in the study. These groups were easily accessible to the researcher in terms of teaching and the logistics of the study. The sample was representative but manageable in terms of data collection.

Data collection tools

All fifty student teachers (who were placed in over 30 different schools) in the sample were invited to take part in the study. The deployment of the data collection tools drew on the validatory work of Morse and Niehaus (209) and involved the sequential acquisition of three sets of data as follows:

(i) Recording in pairs of short co-coaching conversations among student teachers of approximately 10-minute duration;

(ii) A paper-based questionnaire consisting of 18 questions based on an existing tested tool created by the Association of Coaching;

(iii) Memo making by the researcher during informal student discussions that took place after co-coaching conversations;

The coaching programme within the teaching module

The second-year module consisted of 40 hours of taught sessions and 30 hours of blended study, supplemented by 80 hours of independent study. At the beginning of the module, the researcher outlined to the student teachers the requirements and learning objectives of the module. The student teachers were introduced to the idea of professional dialogue as a means of reflecting on and developing practice, that is, science knowledge, teaching knowledge and PCK, and that a way to foster these conversations may be through the use of co-coaching. Student teachers were given basic instruction and access to short cartoon and video clips outlining the key ideas behind co-coaching for professional development. They were also specifically taught and tutored in the STRIDE (strengths, targets, real situation, ideas, decision and evaluate) model for coaching (Thomas and Smith, 2009). Coaching conversations (using STRIDE) were modelled for the student teachers by the researcher and volunteers within the class. The STRIDE model was chosen since it initiates coaching conversations from the positive perspective of personal and professional strengths. This was seen as an important factor since there was a range of science SK within the teaching groups, with only a minority of student teachers having gained an Advanced (post 16 years) qualification.

The student teachers then practised the use of this model with a partner of their choice, in short bursts (approximately 10 minutes), during subsequent weeks to augment the science teaching sessions. At the end of the module (17 weeks), student teachers were asked to reflect on their experience of co-coaching within the module and audio record a short co-coaching session with each other using the STRIDE model to explore their progression as primary pedagogues. Then they were asked to complete a questionnaire to determine whether they felt co-coaching was a viable component of preparation for student primary science teachers.

Ethics

The study was undertaken according to British Education Research Association guidelines (BERA, 2011). The student teachers received a short "information to participants" sheet two weeks before the co-coaching sessions, outlining the purpose and means of the study in order for them to decide whether they would like to take part. It was made clear that all student teachers would be afforded the same educational experience whether they chose to take part in the study or not, and there would be no impact on the module attainment results. With respect to gaining informed consent the student teachers could agree to any combination of aspects of the data collection, for example they could agree to complete the questionnaire but not agree to the analysis of their co-coaching conversations. Twenty seven student teachers agreed to complete the questionnaire and a further sixteen student teachers agreed to supply data for all three collection tools.

Data collection tools and analysis

Questionnaires

To minimize issues of questionnaire validity, the researcher used an existing, extensively trialled questionnaire used by the AC (2004). The original questionnaire consisted of 20 question prompts. Items 1 to 11 were authentic to the original survey, and items 12 to 17 were modified according to the guidelines for coaching in schools (Lofthouse et al., 2010; Tolhurt, 2010) (see Appendix A for a full list of the questions termed throughout the paper as Q1–17). For each prompt, the student teacher participants responded on a five-point Likert scale according to their perceptions of how good co-coaching was at helping them to achieve a particular outcome. The following example illustrates the format adopted:

> Could you rate? (1 = low, 5 = high) how good the coaching programme was at helping you to:
> Item 4: Prioritise your development needs
>
> Item 16: Improve your knowledge of primary science pedagogy

There was a completion rate of 86% (n = 43) for the questionnaires, and the data was collated using Microsoft Excel. Basic descriptive statistics (overall and per item) were then used as a means of deriving meaning from the responses. The data was subsequently downloaded from Microsoft Excel into Statistical Package for Social Sciences (SPSS) version 22 for detailed statistical analysis according to the methods of Koh and Witarsa (2003).

Using SPSS 22, a reliability analysis was undertaken for the questionnaire including the additional items (12–17) as well as the original items 1–11 from the existing questionnaire (AC, 2004). Cronbach's alpha testing revealed a reliability score of $\alpha = 0.943$ which suggested a high degree of internal consistency.

After an initial exploration of the compiled questionnaire data, it was evident that some facets (e.g. understanding of SK for all three science disciplines) formed patterns of association. A basic correlation analysis was undertaken which revealed that certain responses gave rise to similar correlation scores, hence principle component analysis (PCA) was undertaken to explore whether different factors (in this case aspects of co-coaching) were driven by certain underlying variables. This type of analysis has been confirmed as appropriate where the researcher wishes to explore data and highlight generalizations rather than test a specific hypothesis (Field, 2005). This analysis was undertaken using SPSS 22, which was capable of revealing all correlations between components and any clusters of correlations that suggested an underlying linking factor. This approach had the advantage of reducing the size of the data set and highlighting key factors for subsequent analysis.

iPad recordings of short co-coaching sessions

All student teachers on the course were fully conversant with the use of iPads, and towards the end of the module, fifty student teachers in the sample were asked to use them in pairs to audio record a short (approximately 10 minutes) co-coaching conversation with each other. As previously noted, they used the STRIDE model, with student teachers crafting their own questions and considering responses to their partner's questions prior to audio recording. The co-coaching conversations of those student teachers who had consented to the use of all three data collection tools, were then downloaded onto a secure drive and the original recordings deleted from the iPads. The researcher played back the conversations slowly and became familiar with their content; they were then transcribed verbatim and checked before the transcripts were uploaded into NVivo 11 for analysis to determine emergent themes.

(ii) Memo making after small-group discussions

After the co-coaching sessions, the student teachers in the sample formed their own, self-selected small discussion groups to talk over the outcomes and their opinions of the co-coaching experiences. The researcher made notes of these group discussions in the form of short memos to identify student teacher perspectives and attitudes to co-coaching. Only data from the student teachers who consented to all three data collection tools were analysed. There were a range of beliefs expressed; for example, some pertained to how the experience might help them make concrete plans in the future to develop their pedagogy or explore their sense of efficacy. Quotations were recorded as a means of illustrating individual perceptions.

Findings

Effectiveness of co-coaching within science-specific ITE

Quantitative data analysis of the questionnaire responses was used initially to guide further analysis and inform findings for both the main and sub research questions.

PCA (Table 1) shows the result of the pattern matrix which denoted the correlations between items and revealed four principal components within the data. Factors which showed a high degree of communality within clusters were ascribed a phrase encompassing the meaning of that group (shown below), to aid understanding.

The four principal components were identified as follows:

1. **Readiness to teach** (awareness of pedagogical competence, teaching performance and developmental needs associated with raised morale and confidence), corresponding to questions 2, 3, 4, 11, 12 and 16;

2. **Subject knowledge acquisition** (consisting of biology, chemistry and physics knowledge), corresponding to questions 13, 14 and 15;

3. **Proactive development** (planning and goal setting, associated with positive feelings), corresponding to questions 7, 9 and 10;
4. **Optimization of achievement** (evaluation and assessment of achievement and learning opportunities), corresponding to questions 1, 5, 6, 7 and 8.

In this way, the data was reduced from 17 factors to four components, which were then integrated with the analysis of the qualitative data.

[Insert Table 1 near here]

Cluster analysis following coding of the transcripts of co-coaching conversations and small-group discussions revealed four emergent themes supporting the idea that aspects of co-coaching were an effective means of supplementing primary teacher education in science. Further in-depth coding and analysis revealed specific elements of co-coaching practice that facilitated the following aspects of ITE:

(A) Articulation of goals linked to proactive development;
(B) Effective reflection linked to readiness to teach;

(C) Application of new subject knowledge linked to subject knowledge acquisition;

(D) Formulation of solutions linked to optimization of pedagogy.

The integration of quantitative and qualitative data showed there was a high degree of triangulation between both data sets and revealed close alignments among a significant number of factors. For example, quantitative analysis found that student teachers felt co-coaching helped them to reflect effectively on their science SK acquisition, and parallel qualitative analysis revealed they thought co-coaching assisted them with articulating their goals in terms of SK and pedagogy.

Findings pertaining to the emergent themes and subthemes above are detailed in the following sections. Illustrative quotes from co-coaching conversations are reported for each theme.

Articulation of goals

The most striking aspect of the qualitative analysis was that the co-coaching conversations gave the student teachers opportunities to articulate specific goals associated with their education. Interestingly, they reported that they had not had the opportunity to discuss their teaching achievements during their ITE to date. There was clear evidence that the student teachers were able to set themselves targets with respect to both subject and PCK acquisition. The following quote illustrates the very specific nature of some SK goals:

> *I want to develop knowledge and understanding of the eye and how humans see things, and the complex way it works.*

However, the number of goals that referred to SK acquisition were in the minority (a quarter of conversations); the majority referred to developing pedagogy as illustrated by the following quotation:

> *So my goal is to become a more effective science teacher because I feel a lot of my lessons have been very theory based and have not included a lot of practical work.*

Whilst this quote focuses on the lesson content in terms of both SK and mode of delivery, the following comment expresses a wish by the student teacher to develop their PCK around assessment:

> *My goal is to effectively use a wide range of assessment methods to get the most out of my teaching and support the children's learning.*

It is interesting to note the use of the terms "effective", "effectively" and "get the most out of", which suggest a student teacher's emphasis on perceived efficiency.

The following quotation shows significant reflection on the importance of differentiation within primary science teaching:

> *My goal is to [pause] have a more differentiated approach when teaching science. I mean [pause] for me it would be ideal if I could have higher ability work at a level pushing their knowledge beyond the National Curriculum … and lower ability being catered for by the activity challenging them to fulfil their potential.*

Overall, these quotations reveal a very strong conception of effective science pedagogy when judged against Teacher Standard 5, which states teachers must "know when and how to differentiate appropriately, using approaches which enable pupils to be taught effectively" (DfE, 2011).

Effective reflection

It is generally accepted that effective reflection is at the heart of professional development of science teachers (Van Driel et al., 1998). The Reality component of the STRIDE model appeared to act as a conduit for reflection. Analysis revealed that three areas of reflection were referred to predominantly during the co-coaching conversations, namely, meeting specific learning needs, metacognition of professional and academic learning and previous practice.

Reflection on meeting specific learning needs

The majority (three quarters of conversations) referred to student teachers' preparation to meet the specific needs of their learners. The reflections appeared to centre on the established teaching ethos of teaching primary science through a practical "hands on" approach (Harlen, 2011; SCORE, 2008) as illustrated by the following two quotations:

> *There were a lot of benefits of actually physically doing things in terms of discovery learning … they were able to explain what had happened and how it had happened.*

> *Being in a SEND [school containing children with special educational needs or disability] placement, a lot of the children were unable to complete theory based work, so when they were engaged in practical work they made the most progress …*

they were able to get the good results.

The latter comment suggests that the student teacher is exploring the mechanisms by which they believed individual learners with particular needs benefit from a certain method of teaching.

Reflection on metacognition of professional and academic learning

All the student teacher co-coaching conversations revealed that they took the opportunity to reflect upon the strengths of their current practice in terms of skill and knowledge acquisition, as illustrated below:

> *I have learned a* lot *about assessment methods e.g. how you can do it in theory whether it's formative or summative.*

Student teachers also referred to different modalities of teaching in terms of pedagogy:

> *I feel as though, especially with the younger years, questioning and talking about things really works, because that is when you get the most out of them … so that they can take away the key learning points.*

This latter comment also shows a commitment by the student teacher to ensure the fundamental science concepts within the lesson were secured by the young learners.

Reflection on previous practice

A number of exchanges were found to pertain specifically to science teaching and included aspects of reflection on the underlying pedagogy as shown by the following responses:

> *My previous teaching had been mostly theory based but the teaching in this school was very practical [pause] scientific enquiry based.*
>
> *and*
>
> *We did Forest School, where the children experimented with burning materials, it was very child led.*

There were, however, a significant number of responses (approximately half) that suggested student teachers were not afforded sufficient opportunities to teach science in schools. Their reflections indicate that this had impacted negatively as illustrated:

> *But I have only really taught once [pause] one science lesson, so I don't feel I have had enough practice… and maybe more support from the teachers.*

Application of new knowledge

Conversations pertaining to this theme focused on the application of new knowledge linked to subject and pedagogic knowledge acquisition.

Construction of plans for the application of new knowledge

The construction of plans made to extend and refine practice was a widespread element of the conversations (three quarters of student teachers). The plans revolved around elements of experimentation with pedagogic approaches by student teachers as exemplified by the comment below.

> *I will be thinking about combining ideas from teaching … with my assessment knowledge and trying out a few little activities. Then if they work well, putting them into full lessons to try and see which forms of assessment support each other.*

This comment shows the student teacher was comfortable trying out her own ideas for new pedagogical approaches. In addition, student teachers were able to explore more complex scenarios involving transferring knowledge from one curriculum subject to another:

> *I can look at cross-curricular links using discussion in science and use it in different ways. I could use it for different topics… in smaller groups and not just for the whole class, so it could prompt deeper levels of thinking in small groups [pause] I think you could get better results from using discussion and gain a wider range of assessment knowledge then.*

The last quotation is particularly revealing because it shows that the student teacher had synthesized several aspects of her PCK, especially in terms of deploying effective assessment strategies.

Formulation of solutions

Towards the end of the co-coaching conversations (during the Decision and Evaluation phases of STRIDE), student teachers were seen to formulate resolutions in terms of their professional development. Many of these decisions focused on obtaining current resources and seeking advice about future teaching approaches.

Ongoing research for resources

In all cases, when questioned by the coach, the student teachers were confident that they could find resource solutions to support their developing practice:

> *I will do a bit of my own research, reading text books and having a look around on the internet [pause] because obviously you want to provide the children with their best science education and maybe thinking of new ways of improving activities to elicit their ideas.*

It was clear that the co-coaching conversations gave student teachers opportunities to discuss how they could create bespoke learning aids from existing resources.

Seeking advice

Similarly, all student teachers in the sample expressed a desire to seek additional advice on how to move forward with their developing PCK. It was evident from the analysis that there were a range of different professionals that they wanted to gain guidance from, including classroom teachers, science coordinators, university lecturers and their peers. These aspirations were illustrated as follows:

> *I think one option for me would be to ask my colleagues on my new placement … so ask the current class teacher or science coordinator, to see what I can do from there.*

Others voiced the opinion that they would discuss issues with pedagogues of differing experience:

> *I could ask my current peers and lecturers to see if they have any experience with it.*

The following quotation particularly illustrates how the student teacher had chosen a specific aspect they wanted to focus on (in this case discussion) and formulated a cognizant plan for a potential solution.

I think talking to science lecturers is a big help and obviously teachers in school as well, as they are doing the job on a day to day basis. They will have more ideas and a deeper level of knowledge about it than myself [pause] so speaking to people who can help me model discussion in the classroom will really benefit me.

The following sections focus on the sRQ and detail how student teachers felt about the inclusion of co-coaching approaches within the primary science education module.

Student teacher attitudes and beliefs to co-coaching (sRQ)

The student teachers showed predominantly positive attitudes towards the introduction of aspects of co-coaching within their science teacher education sessions, describing them as "very good" and "highly useful".

Positive attitudes

The most prominent positive outcome was the facilitative nature of co-coaching in terms of goal formulation. In response to the question that pertained to goal and target setting, student teachers rated co-coaching as very supportive (averaging a score of 4.36 on a 5-point scale) with a tight standard deviation of 0.57. The percentage of student teachers who rated the co-coaching experience overall (Q17) as helpful or exceptionally helpful was 89.7%. This was echoed by the following qualitative comment about co-coaching:

It was useful to have our peers help with our own goals and have them use their experiences to help us research our goals.

This suggests that the co-coaching conversations encouraged student teachers to set new goals as a result of reflecting on their prior learning. This was most evident during the latter science sessions when student teachers had been working on aspects of co-coaching for several weeks, suggesting an experience effect. In terms of new goal setting (Q8), the majority of student teachers rated the co-coaching experience as positive (4.28 mean score), again with a standard deviation of 0.46. They appeared to appreciate that continual goal setting was a key component in terms of maximizing SK acquisition, and that this process needed to be undertaken in a logical and systematic manner, as illustrated by the following response:

I feel this is a good way to analyse your understanding of science.

This correlated with the high score gained with respect to raising awareness of learning (Q3), which scored 4.16 of 5.00.

Goal-setting aspects within the co-coaching experience also impacted student teacher decision making with respect to their own learning. The student teachers gave the impression that they found co-coaching an effective way of exploring the different possible modes of teaching primary science, as illustrated by the following response:

> *Being asked options to tackle goals allowed me to know there isn't just one way of teaching, there are several ways.*

Some student teachers took the aspect of goal setting and facilitating reflection further and suggested that co-coaching could illuminate deeper reflective practice as illustrated by the following response:

> *It [the co-coaching] was useful to show how teachers are naturally reflective people and how useful this can be for our careers and our science teaching."*

This short response suggests an awareness of how co-coaching could be used as a significant component of not only science-specific aspects of learning but also whole-career progression. This may be because student teachers found co-coaching very helpful in enabling them to prioritize their development needs (Q9) as denoted by the score of 4.04 mean average.

Elements which seemed to illicit weaker responses (in the range of 3.40 to 3.64 mean average) from the student teachers included those centred on the understanding of their level of SK (Q13, Q14 and Q15). This was borne out by the qualitative comments where no student teacher referred to co-coaching helping with understanding levels of specific SK.

Negative attitudes

The attitudes of student teachers to the co-coaching components, although largely positive, were not universally so with Q7 and Q10 being associated with somewhat lower scores (3.76 and 3.9, respectively). The following section illustrates some of the qualitative comments that demonstrate student teachers felt there were some elements that required optimization.

Never experienced it before … might have done without STRIDE being made specific.

This statement suggests that, for this student teacher, the STRIDE model was not particularly helpful, although no alternative was suggested and this was an isolated comment.

Some student teachers showed insights into the inherent limitations of the co-coaching conversations as illustrated by the following comment:

Beneficial, however it was dependent on the quality of questions asked.

This was a particularly perceptive response because it is generally accepted that the quality of co-coaching conversations is, to a large degree, dependent on questioning efficacy (Clutterbuck, 2006).

Finally, it appeared from the qualitative questionnaire data that some student teachers were not wholly convinced that co-coaching was the most effective method of exploring knowledge and skill development. This was mentioned by three pairs specifically, and it is exemplified by the following comment:

It seemed a bit awkward because it was not a real conversation. If it was real, with a tutor that would be really helpful.

This comment suggests that these student teachers felt that their science tutor would be a more effective coach than their peer, but that they still felt that coaching (in some form) could be a really useful tool for their education.

Overall, it was clear that student teachers valued their co-coaching opportunities, and there was a strong voice that co-coaching helped them to contemplate and articulate their goals, which in turn supported them to realize their potential. The following reflection exemplifies this:

Taking part in the questionnaire and coaching conversation for the research project allowed me to consider my targets and aims for teaching. This reflection provided a clear method, which I could employ on placement in order to improve and develop my teaching. I had not come across this method before; an understanding of it has helped me see conversations I've had with my lecturers previously without knowing. Realising this will allow me to develop those conversations further.

This evidence is noteworthy on two levels. First, the student teacher believed co-coaching provided a means by which they could improve and develop their teaching and achieve a degree of autonomy. Second, it is implied that the process assisted them in reflecting on previous learning conversations and afforded a process by which they could sustain and enhance their developing pedagogy.

Discussion

> Coaching is the art and practice of guiding a person or group from where they are toward the greater competence and fulfilment that they desire. (Collins, cited in Stoltzfus, 2005, p. 7)

Central to this research was the notion that co-coaching could be a valuable tool to enhance primary teacher education in terms of science-specific preparation, and that this approach would be acceptable to student teachers. Findings suggest that this was the case. In response to the main research question, there were numerous aspects of co-coaching that could be used to support the acquisition of science-specific knowledge and pedagogy for primary student teachers to foster effective metacognition. The student teachers in this study deliberated extensively during co-coaching sessions on strategies and activities that would enhance the learning of their pupils through their own PCK. During these conversations, they valued the opportunity to discuss their own SK acquisition, pedagogy and PCK with other student teachers, findings common with other studies looking at student teacher collaborations (Harford and MacRuairc, 2008; Nokes *et al.,* 2008).

With respect to science-specific SK acquisition, both quantitative and qualitative data sets supported the idea that co-coaching could be a useful tool to explore this type of knowledge. Whilst exchanges surrounding specific aspects of SK were less prevalent than those pertaining to other knowledge types, there was evidence that student teachers considered and made explicit their SK goals across all three science disciplines, an aspect highlighted as important by Smith (1999).

Surrounding ideas about more general pedagogy, student teachers used the co-coaching conversations to discuss fundamental issues, such as designing effective assessment strategies. Furthermore, reflection on their experience as a coach prompted student teachers to communicate how important it was to be in possession of strong questioning techniques in order to obtain in-depth information from a respondent, a facet that would have a significant impact on their developing pedagogy (Chin, 2007).

In agreement with Ryan's (2003) findings, primary student teachers valued the opportunity to discuss their developing PCK with their peers and achieved a common consensus that practical experience was paramount. There was also evidence that co-coaching facilitated careful reflection on concrete experiences that could illicit children's cognition of key science concepts. Additionally, student teachers were aware of the complexity of linking their own science knowledge to their experiences of effective science teaching in the classroom, a finding resonating with the work of Smith (2007).

Aspects such as supporting student teachers to be proactive in their development by focusing on the modality of the application of their new knowledge were important in agreement with Lampert *et al.* (2013). Equally, the exploration by student teachers of their readiness to teach by formulating solutions appeared to be empowering in concurrence with Averill *et al.* (2016). The findings of this study resonate with others undertaken with student teachers during ITE (Darling-Hammond, 2006; Gelfuso and Dennis, 2014; Sandholtz and Wasserman, 2001) in terms of supporting student teachers to explicitly reflect on aspects of their developing pedagogy by seeking advice from teachers of a similar experience as themselves as well as from more experienced colleagues. Reflection was promoted by the formulation of high-quality questions by the co-coaches in agreement with the work of Celoria and Hemphill (2014). Certainly, despite their inexperience, it is reasonable to state that the coaches fulfilled in essence the remit given by Egan (1994) as "skilled helpers". This finding is in concordance with a US study where pharmacy undergraduates reflected on the importance of being able to construct what they termed "powerful" or "impactful" questions" (Tofade, 2010, p. 2) during peer coaching.

The findings addressing the sub question concerning student teacher attitudes to co-coaching were on the whole positive, although there were some negative comments. However, in terms of belief in whether co-coaching could support their ITE the majority concurred that they felt this was the case. This is quite impressive given that the student teachers had been given a fairly modest allotment of time to experience and deliver co-coaching.

Limitations

It is accepted this was a small-scale study and therefore the findings are not generalizable. In terms of data collection tools, the limitations of questionnaires are well known, including the use of only one item to measure a single construct, lack of reverse questions and participant fatigue (Crano et al., 2015). Perhaps the main limitation of the study as a whole was the amount of time the student teachers were able to devote to practising their co-coaching skills and the brevity of co-coaching conversations. Nevertheless, these were in keeping with other studies involving coaching (Averill et al., 2016; Lampert et al., 2013).

Future directions

Before implementation of this strategy within ITE more widely, it would be necessary to carry out additional research, involving larger numbers of participants, perhaps from different teacher education populations (e.g. postgraduate student teachers and student teachers on alternative ITE routes). A longitudinal study following newly qualified student teachers from induction to the end of their first teaching year would furnish many more co-coaching opportunities and hence determine the generalizability of the findings. Additionally, a more extensive qualitative study based on student teacher co-coaching experiences would be useful and could involve vertical peer support from newly qualified and experienced teachers. In this way, co-coaching could become embedded within a community of ITE practice and become an explicit mechanism for support and continuing professional development within primary schools.

Conclusion

At the heart of this study was an exploration into the viability of introducing co-coaching as a means of supporting the development of primary student teachers with respect to their science teaching. Findings show that co-coaching can provide the means for student teachers to undertake guided professional conversations whereby they can articulate and reflect upon previous and existing practice and plan strategies to augment science-specific subject and pedagogical knowledge. It was also evident that student teachers believed this approach could be a worthwhile addition to their teacher preparation. If found generalizable in the future, this research could inform the design and delivery of ITE programmes in England and potentially further afield as a means of intensifying student teacher opportunities to reflect upon and implement new knowledge within practice.

References

Association for Coaching (AC) (2004), Guidelines for Coaching in Organisations, part 1(D), 12. https://cdn.ymaws.com/associationforcoaching.site-ym.com/resource/resmgr/Articles_&_Handy_Guides/Organisations/Handy_Guides/Guidelines_for_Coaching_in_O.pdf (accessed 12 August 2018)

Anghel, A. and Voica, C. (2013), "Coaching and Mentoring in Bachelor's Degree Programs for Social Workers and Teachers." *Procedia - Social and Behavioural Sciences*, Vol. 92, pp. 36–40.

Averill, R., Drake, M., Anderson, D. and Anthony, G. (2016), "The use of questions within in the moment coaching in initial mathematics teacher education: Enhancing participation, reflection, and co-construction in rehearsals of practice." *Asia-Pacific Journal of Teacher Education*, Vol 44 No. 5, pp. 486-503.

Bochman (2016), "Early career teachers benefit from structured conversations surrounding their developing STEM based pedagogy." *Studies in Science Education*, Vol. 6, pp. 35-48.

Borko, H. and Livingston, C. (1989), "Cognition and Improvisation: Differences in Mathematics Instruction by Expert and Novice Teachers." *American Educational Research Journal*, Vol. 26 No. 4, pp. 473-498.

British Education Research Association (BERA) (2011), Ethical guidelines for research. www.bera.ac.uk/files/2008/09/ethica1.pdf (accessed 12August 2018)

Celoria, D. and Hemphill, D. (2014), "Coaching from the coaches' perspective: A process-oriented focus." International Journal of Mentoring and Coaching in Education, Vol. 3 No. 1, pp. 72-85.

Centre for the Use of Research and Evidence in Education (CUREE) (2005), "Mentoring and Coaching CPD Capacity Building Project: National Framework for Mentoring and Coaching." http://www.curee.co.uk/files/publication/1219925968/National-framework-for-mentoring-and-coaching.pdf (accessed 1 August 2018)

Chin C. (2007), "Teacher questioning in science classrooms: what approaches stimulate productive thinking?" *Journal of Research in Science Teaching.* Vol. 44 No. 6, pp. 815–843.

Clutterbuck, D. (2006), "Seven coaching conversations." https://www.davidclutterbuckpartnership.com/wp-content/uploads/Seven-coaching-conversations.pdf (accessed 20 August 2018)

Cole, B. and McGuire, M. (2012), "Real-World Problems: Engaging Young Learners in Critical Thinking." *Social Studies and the Young Learner* Vol. 24 No. 4, pp. 15–17.

Cox, E. (2012), *Coaching Understood: A Pragmatic Inquiry into the Coaching Process.* SAGE, London.

Crano, W., Brewer, M. and Lac, A. (2015), *Principles and Methods of Social Research.* Routledge. London.

Creswell, J. and Plano Clark, V. (2011), *Designing and conducting mixed methods research*. 2nd Ed. SAGE, Thousand Oaks, CA.

Darling-Hammond, L. (2006), *Powerful teacher education: Lessons from exemplary programs.* Jossey-Bass, San Francisco, CA.

Department for Education (DfE) (2011), "Teachers' Standards Guidance for school leaders, school staff and governing bodies." https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/665520/Teachers__Standards.pdf (accessed 1 July 2018)

Department for Education (DfE) (2013), "The National Curriculum in England Key stages 1 and 2 framework document." https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/425601/PRIMARY_national_curriculum.pdf (accessed 1 August 2018)

Downey, M. (1999*), Effective coaching*. Orion Business Books, London.

Egan, G. (1994), *The Skilled Helper: a Problem Management Approach to Helping.* Pacific Brooks/Cole Publishing Company, Pacific Grove.

Eick, C. and Reed, C. (2002), "What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice." *Science Education* Vol. 20, pp. 135-156.

Field, A. (2005), *Discovering Statistics Using SPSS*, 2nd Edn., SAGE, London.

Gelfuso, A., and Dennis, D. (2014), "Getting reflection off the page: The challenges of developing support structures for pre-service teacher reflection." *Teaching and Teacher Education*, Vol. 38, pp. 1 –11.

Goethals, G., Winston, G., and Zimmerman, D. (1999), "Students Educating Students: The Emerging Role of Peer Effects in Higher Education." Williams Project on the Economics of Higher Education. Forum Futures, Forum Publishing, pp. 25-45.

Harford , J. and Macruairc, G. (2008) "Engaging student teachers in meaningful reflective practice." *Teaching and Teacher Education*, Vol. 24 No. 7, pp. 1884-1892.

Hampton, G., Rhodes, C. and Stokes, M. (2004), *A Practical Guide to Mentoring, Coaching and Peer-networking: Teacher Professional Development in Schools and Colleges*. Routledge, London.

Harlen, W. (2001), *Primary Science: Taking the Plunge. How To Teach Science More Effectively for Ages 5 to 12*. 2nd Edn. Heinemann, Portsmouth NH USA.

Harlen, W. (2011), ASE guide to primary science education, ASE, Hatfield.

Harlen, W. and Qualter, A. (2018), *The Teaching of Science in Primary Scho*ols. 7th Ed. Routledge. London.

Healey M. (2005), "Linking research and teaching: disciplinary spaces" in: Barnett, R. (Ed.) *Reshaping the university: new relationships between research, scholarship and teaching*, McGraw Hill/Open University Press, pp.30-42.

Jewett, P. and MacPhee, D. (2012), "A dialogic conception of learning: collaborative peer coaching", International Journal of Mentoring and Coaching in Education, Vol. 1 No. 1, pp.12-23.

Jones, L., Tones, S. and Foulkes, G. (2018), "Mentoring associate teachers in initial teacher education: the value of dialogic feedback", International Journal of Mentoring and Coaching in Education, Vol. 7 No. 2, pp.127-138.

Joyce, B. and Showers, B. (1980), "Improving Inservice Training: The Messages of Research." *Educational Leadership* Vol. 37, pp. 379-385.

Koh, K. and Witarsa, M. (2003), "A review of data analysis for behavioural sciences using SPSS." *Journal of Educational and Behavioural Statistics* Vol. 28, pp. 83-88.

Lampert, M., Franke, M., Kazemi, E., Ghousseini, H., Turrou, A. C., Beasley, H. and Crowe, K. (2013), "Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching." *Journal of Teacher Education*, Vol. 64 No. 3, pp. 226–243

Law, H. (2013), *The Psychology of Coaching, Mentoring and Learning*. John Wiley and Sons. West Sussex, UK.

Lofthouse, R., Leat, D. and Towler, C. (2010), "Coaching for teaching and learning: a practical guide for schools." Guidance report. CfBT Education Trust 1-37 available at https://www.gov.uk/government/publications/coaching-for-teaching-and-learning-a-practical-guide-for-schools (accessed 20 October 2018)

Lofthouse, R. and Leat, D. (2013), "An activity theory perspective on peer coaching", International Journal of Mentoring and Coaching in Education, Vol. 2 No. 1, pp.8-20.

Luehmann, A. (2007), "Identity development as a lens to science teacher preparation." *Science Education* Vol. 91, pp. 822-839.

Morse, J. and Niehaus, L. (2009), *Mixed method design: Principles and procedures.* Left Coast Press, Walnut Creek, CA.

Nokes, J., Bullough, R., Egan, W., Birrell, J. and Hansen, J. (2008), "The paired-placement of student teachers: An alternative to traditional placements in secondary school." *Teaching and Teacher Education* Vol. 24 No. 8, pp. 2168-2177.

Parsloe, E. (1995), *Coaching, mentoring and Assessing: A practical guide to developing competence*, Kogan Page, New York.

Parker, P., Hall, D., and Kram, K. (2008), "Peer coaching: A relational process for accelerating career learning." *Academy of Management Learning & Education*, Vol. 7, pp. 487-503.

Podsen, I. and Denmark, V. (2006), Coaching and Mentoring First-Year and Student Teachers 2nd Ed. Routledge, Oxon, UK.

Royer, J., Mestre, J., and Dufresne, R. (2005), "Introduction to framing the transfer problem, in Mestre, J. (Ed.) *Transfer of learning from a multidisciplinary perspective.* Information Age Publishing, Greenwich, CT.

Ryan, C. (2003), "Becoming a Teacher of Primary Science: integrating theory and practice." *Teachers and Teaching: Theory and Practice*, Vol. 9 No. 4, pp. 333-349.

Salter, T. (2015), "Equality of mentoring and coaching opportunity: making both available to pre-service teachers", International Journal of Mentoring and Coaching in Education, Vol. 4 No. 1, pp.69-82.

Sandholtz, J. and Wasserman, K. (2001), "Student and Cooperating Teachers: Contrasting Experiences in Teacher Preparation Programs." *Action in Teacher Education*, Vol. 23 No. 3, pp. 54-65.

Schön, D. (1983), *The Reflective Practitioner: how professionals think in action,* Basic Books. New York.

SCORE (2008), “Practical work in science: a report and proposal for a strategic framework.” pp. 1-19 available at http://www.score-education.org/downloads/practical_work/report.pdf (Accessed 1 July 2018)

Shulman, L. (1986), “Those who understand: Knowledge growth in teaching.” *Educational Researcher*, Vol. 15, pp. 9-23.

Simpson, A. (2016), “Dialogic teaching in the initial teacher education classroom: Everyone's Voice will be Heard”, *Research Papers in Education*, 31(1), 89-106

Smith, R. (1999), Piecing it together: student teachers building their repertoires in primary science, Teaching and Teacher Education, Vol. 15No. 3, pp. 301–314.

Smith, R. (2007), “Developing professional identities and knowledge: becoming primary teachers”, *Teachers and Teaching: Theory and Practice*, Vol. 13 No. 4, pp. 377-397.

Sorenson, P. (2012), “Mentoring and Coaching for School Teachers’ Initial Teacher Education and Induction”, in Fletcher, S. and Mullen, C. (Eds*) The SAGE Handbook of Mentoring and Coaching in Education.* SAGE, Thousand Oaks, CA, pp.201–14.

Stewart, L. and Palmer, S. (2009), "Capitalizing on coaching investment: enhancing coaching transfer", *Development and Learning in Organizations: An International Journal*, Vol. 23 No. 3, pp. 14-17.

Stoltzfus, T. (2005), *In Leadership Coaching: The Discipline, Skills and Heart of a Christian Coach,* BookSurge Publishing, Virginia Beach, VA.

Thomas, W. and Smith, A. (2009), *Coaching solutions: Practical ways to improve performance in education,* Network Continuum Education, London.

Tofade, T. (2010), “Coaching Younger Practitioners and Students Using Components of the Co-active Coaching Model.” *American Journal of Pharmaceutical Education,* Vol. 74 No. 3, pp. 51.

Tolhurt, J. (2010), *The Essential Guide to Coaching and Mentoring: Practical Skills for Teachers.* Pearson Education Limited, London.

Topping, K. (1996), “The effectiveness of peer tutoring in further and higher education: A typology and review of the literature.” *Higher Education*, Vol. 32 No.3, pp. 321–345

Van Driel, J., Verloop, N. and de Vos, W. (1998), “Developing science teachers’ pedagogical content knowledge.” *Journal of Research in Science Teaching*, Vol. 35 No.6, pp. 673-695

Wall, T. (2016), “Turning practitioners into practitioner researchers*”* in Helyler, R. (Ed.) *Facilitating Work-Based Learning: A Handbook for Tutors*, Palgrave, London.

Zimmerman, C. (2005), “The Development of Scientific Reasoning Skills: What Psychologists Contribute to an Understanding of Elementary Science Learning.” NRCC http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_080105.pdf (accessed 1 July 2018)

Zwart, R., Wubbels, T., Bergen, T. and Bolhuis, S. (2007), “Experienced teacher learning within the context of reciprocal peer coaching”, Teachers and Teaching, Vol. 13No. 2, pp. 165-187.

Appendix A

The questionnaire for the accrual of quantitative data was based on the "Guidelines for Coaching in Organisations" from the Association for Coaching (2004). Items 1–11 were authentic to the original survey; items 12–18 were modified to explore science teacher education.

How good? (1 = low 5 = high) was the co-coaching programme at helping you to:

1. Assess your current levels of competence	1 2 3 4 5
2. Improve your teaching performance	1 2 3 4 5
3. Become more aware of your learning	1 2 3 4 5
4. Prioritise your development needs	1 2 3 4 5
5. Maximise any learning opportunities	1 2 3 4 5
6. Set yourself development goals or targets	1 2 3 4 5
7. Monitor and/or evaluate the achievement of your objectives	1 2 3 4 5
8. Set yourself new goals	1 2 3 4 5
9. Create a Personal Development Plan	1 2 3 4 5
10. Feel more positive about your development	1 2 3 4 5
11. Raise your morale	1 2 3 4 5
12. Increase your confidence	1 2 3 4 5
13. Increase your subject knowledge of Biology	1 2 3 4 5
14. Increase your subject knowledge of Chemistry	1 2 3 4 5
15. Increase your subject knowledge of Physics	1 2 3 4 5
16. Understand your level of primary science pedagogy.	1 2 3 4 5
17. Improve your overall primary science teaching	1 2 3 4 5

18. Please add anything else you wish to say about your co-coaching

Table 1 - Principal component analysis of quantitative questionnaire data

		Component			
		Readiness to teach	**Subject knowledge acquisition**	**Proactive development**	**Optimization of achievement**
1	Assess competence	0.095	-0.348	-0.506	*0.698*
2	Improve performance	*0.759*	-0.103	0.006	-0.37
3	Awareness of learning	*0.671*	-0.263	-0.390	-0.067
4	Prioritize dev. needs	*0.730*	-0.037	-0.172	0.174
5	Learning opportunities	0.213	-0.310	0.033	*0.596*
6	Goal setting	-0.19	0.138	0.025	*0.955*
7	Evaluation of achievement	0.205	-0.297	*0.458*	*0.424*
8	New goal setting	0.131	0.208	0.262	*0.746*
9	Personal dev. planning	0.177	-0.392	*0.580*	0.358
10	Positive feelings of development	0.360	-0.356	*0.464*	0.106
11	Raise morale	*0.781*	0.036	0.085	0.211
12	Increase confidence	*0.848*	0.011	0.256	-0.167
13	Biology SK acquisition	0.084	*-0.930*	-0.044	-0.080
14	Chemistry SK acquisition	0.041	*-0.952*	-0.077	-0.046
15	Physics SK acquisition	-0.074	*-0.971*	0.164	0.004
16	Pedagogic understanding	*0.864*	0.047	0.096	0.024

- The extraction method used for principal component analysis was the Oblimin with Kaiser normalization rotation method. The rotation type used was oblique because it was assumed there were no strong theoretical grounds to assume dependence. The rotation converged in 23 iterations which was deemed acceptable for this type of relatively small data set.
- There were 16 variables so communalities greater than 0.40 were deemed significant.
- The vertical column represents each factor and the rows represent the loadings of each variable onto the factor.
- The degree of loading is shown in the vertical columns of the table. Notably high loading factors are italicized.