The value of short Earth Science CPD for trainee primary school teachers.

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Abstract

The paper investigates the potential of earth science for the development of primary school science. The evaluation from workshops run by the Earth Science Education Unit for trainee primary teachers was appraised to assess the effectiveness of the short Continuing Professional Development (CPD) programmes over the period 2009-2015. Trainee teacher comments are analysed using thematic analysis which identified points recognised by Guskey (2000) as being the most important ideas for effective CPD programmes. Despite these workshops being short, lasting generally less than two hours each, the conclusion reached was that they offered useful teaching ideas, resources and background information which the trainees could and would apply in the classroom.

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Introduction

The Earth Science Education Unit (ESEU) was founded as a pilot scheme in 1999, and rolled out across the United Kingdom in 2002, to encourage and enhance earth science teaching by both primary and secondary teachers. The Unit was based at Keele University under the leadership of Professor Chris King and initially sponsored for 15 years by UK Oil and Gas (2003-2018). Earth Science CPD sessions which delivered the requirements of the National Curriculum and beyond, were presented by a group of trained volunteers, themselves earth scientists, who offered enthusiastic and accurate information and methodology using low cost resources. Evaluation of the secondary programme was carried out in 2009 (Lydon & King, 2009). The programmes given to trainee primary teachers over the period 2009-2015 were thoroughly assessed in 2018. The workshops had been revised in 2014 to comply with updates in the primary science curriculum.
The current English primary curriculum has Earth Science topics scattered within the geography and science curricula. The topics are not well linked within the primary curriculum, for example: knowledge of where volcanoes and earthquakes are located are learnt in geography between ages 7-11 (Key stage 2) but are not related to forces in the Key Stage 2 science curriculum. Key stage 2 (KS2) primary science requires knowledge of rocks to be identified at age 7-8, as well as fossils and some understanding of soil formation. Fossils are looked at again at age 10-11 within evolution, the basic water cycle is taught in geography and mentioned again in science at age 8-9, where it may be linked with changes in water states: condensation and evaporation.

The Office for Standards in Education in England, Ofsted (2013, page 5) stated that where primary science teachers and science leaders had received subject-specific science CPD sessions, primary science teaching was more effective; in Ofsted's words "more likely to be outstanding". Australian primary science teachers affirmed that short (up to four-hour long) CPD workshops increased their self-efficacy and had a positive influence on their science teaching (McKinnon & Lamberts, 2014). However, previously Adey et al., (2004) had suggested that the only short CPD courses that would have any real impact on teaching would need to be very specific, perhaps on software applications or assessment methods. The Wellcome Trust report (2013) found that where science subject leaders had received science CPD they could better help any primary teacher in their school who was struggling with science. Shallcross et al., (2010) suggested there was a need for good integrated science CPD which included background information as well as specific-subject knowledge and pedagogy. Abrahams et al., (2012) also felt that there was a need for CPD, especially for practical work which they thought did not always have clear objectives but was often used to provide a 'fun' lesson. They felt there was a need to make practical work more effective, and their Getting Practical CPD programme was designed to support practical work in science. There has been little published research on the effectiveness of primary science CPD programmes to date. Primary teacher training establishments concentrate more on the pedagogy of teaching science rather than actual information, which given that most primary trainees (and teachers) are non-scientists is disappointing, (Wellcome Trust, 2013). Discussion with primary teachers in my county during my research revealed disappointment at the lack of actual science knowledge and application available during primary science CPD they had attended. (Balmer, 2019).

The primary earth science workshops I taught were specifically designed to meet the needs of primary teachers with non-science backgrounds. Evaluation of the secondary ESEU workshop data by Lydon

and King (2009) showed that this CPD gave teachers both subject content knowledge and pedagogical knowledge, increasing their confidence and effectiveness. Changes to most of these secondary teachers' teaching methods were long term, as shown by a follow up survey carried out a year after the workshop (Lydon & King, 2009). I analysed the ESEU data collected from the primary trainee teachers' evaluation forms using thematic coding after the idea proposed by Braun and Clarke (2006). The themes identified were the participants' reactions, their learning and the proposed use of the new skills and knowledge gained from the CPD activities (Guskey, 2000).The themes related well to Guskey's (2000) proposals of evaluating levels of CPD outcomes, which are described later.

1. Method of ESEU data collection from CPD primary workshops held in England, 2009-2015

The ESEU data were collected during trainee teacher workshops over the period 2009-2015. The workshops were run in a wide range of primary teacher training institutions by their local ESEU-trained facilitator. These various training institutions throughout England (**no change 2.5)** had requested a free primary earth science workshop through Keele University. All workshop facilitators had been trained by the ESEU and completed annual updating training, to keep them in touch with new concepts in earth science and curriculum changes, particularly with the introduction of the new primary science curriculum in 2013/14.

There were no ethical issues involved. Permission was given by the ESEU to use those forms where participants had signed to say they were happy for their comments to be used. All photographs used had permission for use by the trainees involved.

The primary trainee teachers participating in the ESEU workshops were from a range of training institutions and programmes across England. Four different teacher training programmes were available during this period:

- Teach First: a programme where participants work in schools and are fully paid whilst on a two-year training course. The trainees, who have a wide range of backgrounds and experience are supported by tutors and day release sessions
- Post Graduate Certificate of Education (PGCE)
- Bachelor of Education (BAEd) courses
- SCITT courses: school centred initial teacher training programmes.

The trainees' backgrounds and ages varied greatly, some were British nationals, others were from overseas, these data do not show the differences. The workshops comprise a series of low-cost, practical investigations and simulations which can take place in any classroom and are each about 90 minutes long. In the workshops, the participants were encouraged to work on as many of the investigations or simulations as they could, in order to gain as much experience as possible during the time available. The facilitator worked with the trainees, responding to theoretical and practical questions as they arose. The participants were asked to evaluate the workshop sessions after they had taken part in them and the data and comments from these evaluations, collected by the ESEU were made available for analysis. The evaluation form requested background information about the trainee teacher's science and earth science training since taking GCSE and whether the trainee teacher felt confident teaching earth science before the workshop input. Given the large sample size, the evaluation forms used were the first 25% of forms completed for each year, taken from the archive in the order they had been collected at Keele. This is not necessarily the order in which the workshops were taught.

After completing the workshop, each participant was given the resource lists, risk assessments and workshop instructions for the three primary workshops taught, so they could use the materials in their schools immediately and pass the workshop information to their peers. The photograph shown in Figure 1 shows trainee teachers investigating soil.

Figure 1 Trainee teachers investigating soil

It was not feasible to examine all the evaluation forms for the extent of the programme (some 5000+ forms). A simple random sample of 25% forms for each year the workshop programme was taught, 2009 to 2015, (1395 forms) was analysed. The forms analysed were from teacher training establishments across England. The ESEU data are partly in Likert scale form, but the part of the evaluation of most interest to me was the 'comments section' written immediately after the workshop. The ESEU evaluation form requested data in several formats:

- Background information on trainee teachers
- Eleven questions to be answered on a Likert scale referring to amount of earth science that trainees may be teaching (most of these data were not used in this study)
- Participants' comments about their workshop experience (these data have been used for the purpose of this study).

When analysing these data, I transcribed all the comments on the sampled evaluation sheets for determining themes in order to be able to analyse them using thematic analysis (Braun & Clarke, 2006). The comments were linked to form themes, described later.

2 Results of the ESEU data collection: The data

The background information data were extracted from the evaluation forms and tabulated so that different years could be compared as seen in Table 1.

From Table1 it can be seen that the number of female trainees participating in the workshops is much greater than the number of male participants, who are around one-fifth of the overall total (22%), in line with Government statistics for 2015 which show that 85% of primary teachers are female (DfE, 2015 p7).

Table 1 Compilation background data of primary trainee teachers taken from the data on the ESEU evaluation forms 2009-2015.

	2009	2010	2011	2012	2013	2014	2015	Total	%
Total number of trainees in workshops in year	424	452	688	1252	1196	1144	424	5580	
No. of evaluation forms used in study	106	113	172	313	299	286	106	1395	25%
No. of females in study	84	101	129	253	217	233	78	1095	78%
No. of males in study	22	12	43	60	82	53	28	300	22%
Earth Science studied to 16	62	73	108	163	149	207	61	823	59%
Earth Science studied to 16+	13	9	15	29	21	26	8	121	8.7%
Earth science as minor part of degree	17	8	15	39	26	26	3	134	9.7%
Earth Science as major part of degree	9	5	5	4	13	2	1	39	2.8%

The number of trainees who stated they had learnt any earth science or geology during GCSE was 59%. A small amount of earth science was included in GCSE physics/chemistry up to 2014, but the respondents may not have appreciated earth science as a specific topic within the curriculum. The workshops evaluated mostly took place before the 2014 changes in the National Curriculum which have now virtually removed earth science from the secondary science curriculum, placing it in geography with a more social emphasis, which means that the next generation of teacher trainee recruits will probably have studied even less earth science, from a science perspective, up to the age of 16. There is, however, more earth science in the primary curriculum from 2014. About 10% of trainees said they had studied earth science / geology after GCSE with some stating it was a minor part of a degree course (approximately 10%) whilst others had studied earth science as a larger part of their degree (2.8%). But overall, few primary trainee teachers in my sample have science degrees (Table 2), although it is not necessarily the case that those who do are able to teach science better than their colleagues as they sometimes cannot relate their science studies to the level required in primary school (PSST, 2016).

Table 2 Number of trainee teachers with science degrees attending workshops

	2009	2010	2011	2012	2013	2014	2015	Totals	% of total
Number of trainees participating:	106	113	172	313	299	286	106	1395	
Degree in biology	7	3	1	2	10	2	0	25	1.8%
Degree in chemistry	0	1	0	1	1	2	0	5	0.4%
Degree in physics	1	1	1	1	2	0	0	6	0.43%
Degree in earth science	1	1	3	4	1	0	0	10	0.72%
Degree in geology	0	0	0	0	0	0	0	0	0%

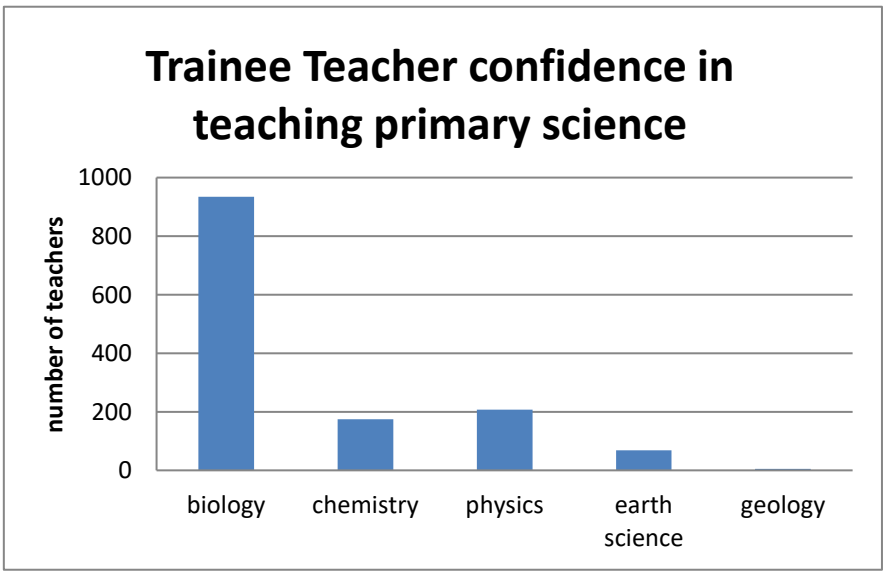
Further data from the evaluation form is shown in Table 3 which shows percentage numbers of trainees' confidence in teaching primary science. (Note: some teachers were confident in more than one subject.)

Table 3 Percentage of trainee teachers who felt confident at teaching particular science subjects

	2009	2010	2011	2012	2013	2014	2015	Average %
Number of trainees participating:	106	113	172	313	299	286	106	
Teaching confidence in biology	59	64	66	67	62	81	54	65%
Teaching confidence in chemistry	15	14	12	8	11	13	28	14%
Teaching confidence in physics	20	16	16	15	13	12	21	16%
Teaching confidence in earth science	3	2	6	5	6	4	6	4.6%
Teaching confidence in geology	2	0	0	0	0	3	1	0.85%
Teaching confidence in all	1	0	2	1	1	1	2	1.1%
No confidence	0	2	2	3	6	3	25	5.9%

The data in Table 3 show that between 2009 and 2015, 65% of the participants stated they were confident in teaching primary biology, but confidence in teaching chemistry, physics, earth science and geology (the other sciences in the primary science curriculum) was much lower at 14%, 16%, 4.6% and 0.85% respectively. These data are shown in Figure 2.

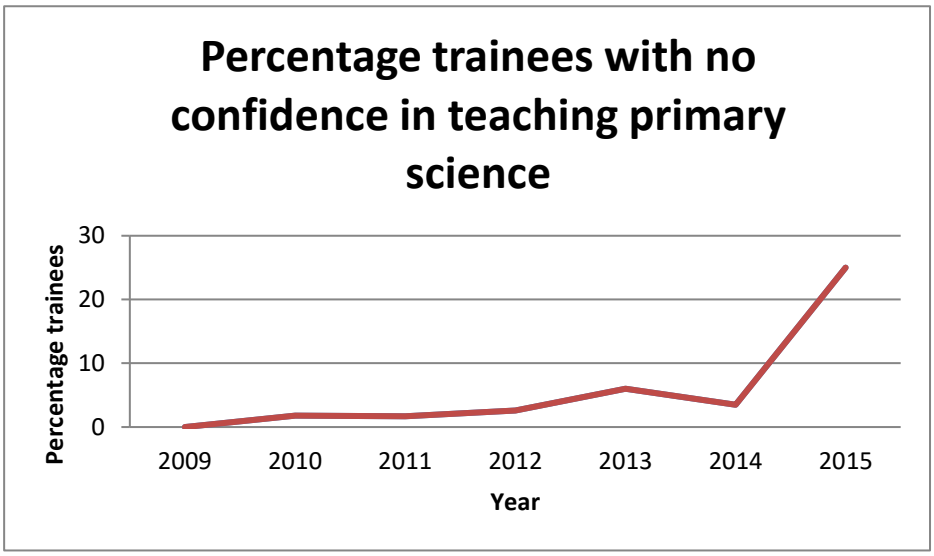
Figure 2 Bar graph showing overall trainee teacher confidence in teaching primary science from 2009-2015



In 2015, however, confidence in teaching biology within the sample, had fallen from a high the previous year, to its lowest level, whilst the same year, 2015, showed an increase in confidence in teaching chemistry and physics. This difference between chemistry and physics, on the one hand, and biology, on the other, may relate to the 2014 changes to the primary curriculum, which reduced the amount of chemistry and physics in the curriculum. Overall, though, a much higher percentage of teachers had no confidence in teaching primary science in 2015 (25%), a huge increase on previous years, as seen in Figure 3. If teachers are not confident in their ability to teach a subject, this can often affect their enthusiasm and ability to enthuse their pupils (Aalderen-Smeets et al., 2013). Across the 2009-2015 period only 1.1% of the trainees stated that they were confident at teaching all of primary science.

Confidence in teaching geology/earth science was low (averaging 5.7% across the 2009-2015 period) before the workshop, as stated by the trainees on the evaluation form (Figure 3).

Figure 3 Percentage of teacher trainee participants at ESEU workshops stating they had no confidence in teaching primary science prior to participating in the workshop.



One worrying feature is that the graph suggests an increasing percentage of primary trainees who state they have no confidence in teaching primary science (Figure 3). Since the major increase occurs after the implementation of the new National Curriculum it may be that trainees feel less confident with the new programmes and their assessment procedures.

A Likert scale was used in the CPD evaluation form to ascertain whether the respondents felt the workshop had increased their confidence. All participants (no=1395) indicated that their confidence had increased and many of the comments used in the later analysis stated that their knowledge and understanding had improved.

3.1 Trainee comments written on the ESEU evaluation forms

The trainees were asked to comment about their workshop experience on the evaluation form. There were 2365 comments from the 1395 participants; these were transcribed and classified into six themes in the following manner, as described by Braun and Clarke (2006). A list was made of all the comments and these were initially grouped under headings (Table 5) which were then categorised to form themes. These themes were identified as the main benefits the trainees had identified from the workshop.

The themes are described below and mentions shown in table 4.

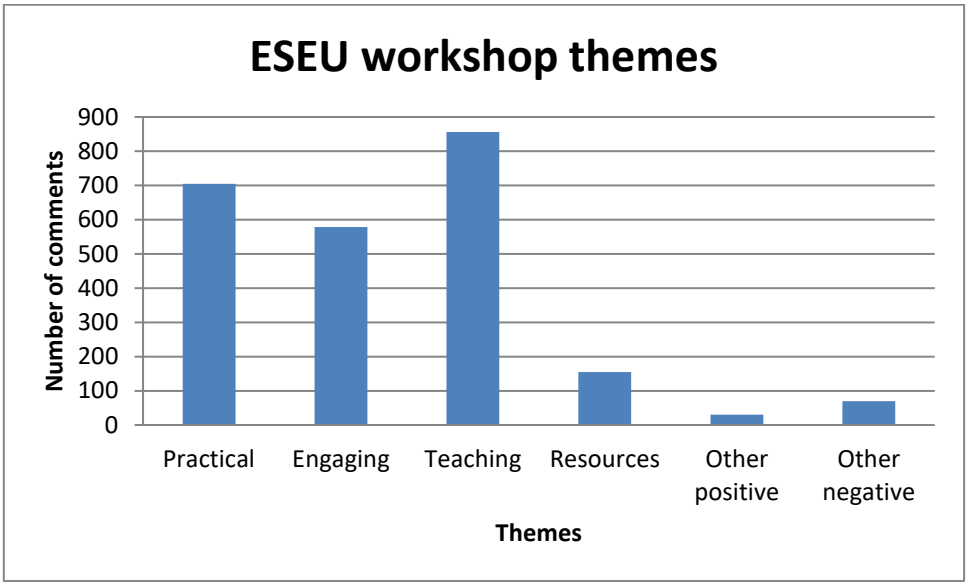
- Theme 1 Practical: 705 comments relating to effectiveness of practical activities and investigations, and the usefulness of the CPD in the classroom. For example: ‘very hands on workshop providing valuable information’ and ‘effective interactive investigations shown’.
- Theme 2 Engaging: 578 participants’ comments about how workshops would be received by primary children and learning points which could be made. Examples ‘inspiring activities’ and ’relevant local issues could be used’.
- Theme 3 Teaching: 856 comments about the ease of delivery, use of good vocabulary, differentiation uses, level of approach, clarity of explanations: i.e. ‘ simple explanations of correct vocabulary’; ’range of practical work to suit all levels’.
- Theme 4 Resources: 155 comments related to the simplicity, availability and inexpensive use of everyday items for the investigations and simulations. Comments such as ‘no need for laboratory equipment’, ‘use of empty plastic bottles and yoghurt cups a good idea’.
- Theme 5:30 positive comments including ones on length and timing of the CPD workshop, and how the participants felt towards teaching earth science after the workshops. Points made included ‘no overload of ideas’ and ‘just right length of CPD’.
- Theme 6: 41 negative comments including those from participants who did not intend to use the exercises in their classes**.** One comment suggested that the workshop was too slow and too long.

Table 4 Composite table of comments and themes from participants about ESEU CPD workshops 2009-2015

Comments from evaluation forms	Theme	2009	2010	2011	2012	2013	2014	2015	Total
Practical / Hands-on	1	46	38	67	81	77	87	24	420
Models	1	0	4	0	0	1	1	0	6
Good experiments	1	2	4	4	20	19	14	20	83
Interactive/investigative	1	2	1	9	17	15	10	2	57
Useful/valuable/effective	1	10	0	18	40	20	50	1	139
Interesting/good background	2	15	4	12	40	16	0	18	105
Engaging/enjoyable/fun	2	23	12	36	39	42	27	9	188
Fantastic/brilliant/excellent	2	13	17	9	11	23	0	18	91
Creative/inspiring/	2	0	6	0	2	0	5	0	13
Presentation/ambience	2	0	0	1	1	0	1	0	3
Presenter’s knowledge	2	0	0	5	14	33	30	10	92
Discussion /informal/experiences	2	4	4	6	3	3	5	1	26
Enthusiasm/passion for ES	2	0	2	8	14	8	6	4	42
Answered participants’ questions	2	0	1	2	5	2	6	2	18
Great teaching ideas	3	16	19	29	62	86	65	20	297
Good information/concepts	3	12	8	13	30	24	23	14	124
Useful in class/lesson plans	3	0	19	5	26	35	32	18	135
Relevant to curriculum	3	0	7	23	13	7	22	6	78
Right level/easy instructions	3	0	3	6	2	12	4	2	29
Extensions	3	0	0	1	1	0	0	0	2
Adaptable	3	0	1	1	4	2	0	0	8
Differentiation	3	0	0	0	2	4	0	0	6
Good for SEN	3	0	0	0	0	1	0	0	1
Fits own teaching	3	3	0	2	6	1	4	0	16
Easy delivery	3	8	0	1	2	0	0	0	11
Useful vocabulary	3	2	1	1	0	0	2	0	6
Gives confidence/deliverable	3	2	9	3	18	11	8	5	56
Cross curricula links	3	3	0	1	0	2	3	0	9
Misconceptions	3	0	0	0	2	0	0	0	2
Relates to real world	3	0	0	0	0	4	3	3	10
Correlates life skills	3	2	1	0	0	0	0	1	4
Improves thinking skills	3	2	1	0	1	2	1	0	7
Evokes curiosity/insightful	3	0	0	2	1	0	4	0	7
Improves understanding	3	0	0	5	4	0	18	6	33
Improves own knowledge	3	10	0	0	0	0	4	1	15
Useful resources	4	18	15	9	14	27	26	11	120
Good CD ROMs	4	0	0	5	0	1	5	13	24
Clear explanations	4	6	0	0	0	0	3	0	9

Knowledge giving/good info.	4	2	0	0	0	0	0	0	2
Not overloaded	5	3	0	1	4	0	2	0	10
Too short	5	1	0	3	16	1	7	2	30

Figure 4 Workshop theme analysis



In the 'practical' theme, trainees' comments stated that the workshop sessions provided 'effective simulations and hands-on practical investigations' that were both interactive and investigative. Trainees felt these investigations would appeal to the children's imagination and that pupils would identify with the concepts from the investigations, thus dispelling alternative conceptions, evoking curiosity and improving thinking skills and knowledge and understanding. This can be seen as effective pedagogy, enabling learning. The workshops gave ideas for making a simple water-cycle model; practical activities to show how soil erosion could be curtailed by vegetation; and using a piece of guttering to replicate a river's flow, simulating relevant experiences that children may experience in their local area.

The 'engaging' theme brought together the trainees' comments about their feelings of working on the earth science investigations and how they thought these investigations and simulations would run in their primary classroom. They also commented that 'the investigations would provoke discussion and the asking of many questions', again invoking effective learning pedagogy as children would recall the practical side of the investigations and working together

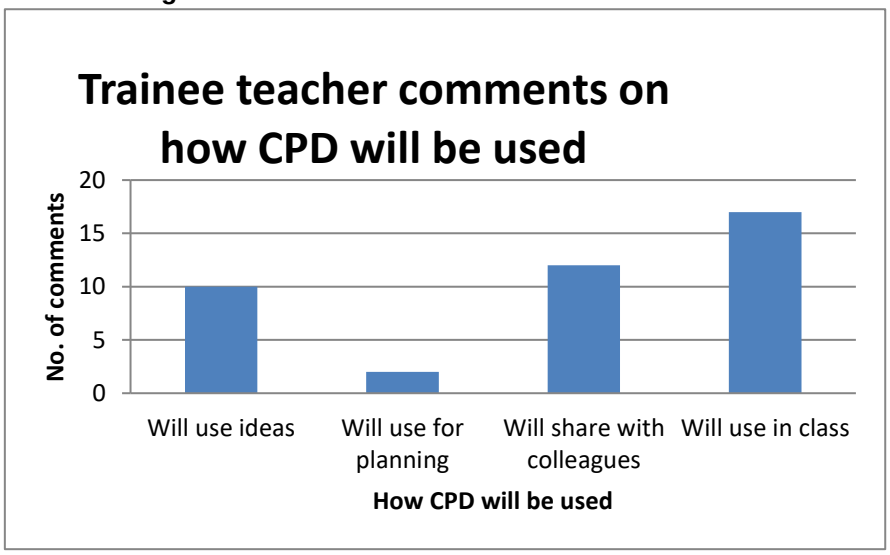
The 'teaching' theme included points about the use of appropriate and relevant vocabulary, the ease of delivery, and the fact that the experiments could be differentiated for differing abilities. Using scientific language in an appropriate setting was an important point made; children could visibly see evaporation and condensation in the water cycle simulation, and permeability could be measured in the rock and soil investigations. Trainees stated that 'they could use the workshop materials in their own teaching and use them for cross-curricular purposes as well'.

The 'resources' theme recognised that these investigations could be carried out using simple equipment made from everyday items, for example, lemonade bottles and coffee filters. Trainees also acknowledged the usefulness of the CDROM which contained all the necessary investigative ideas and risk assessments.

Some of the positive points raised were the clear explanations given by facilitators, and the fact that the materials could easily be differentiated and also used for SEN work. The subject knowledge input was appreciated as was the discussion which arose during the workshop, as all the facilitators would endeavour to explain the scientific concepts behind some of the practical investigations and simulations. Negative points that were made by trainees were on the length of the CPD ('too short') and 'the need for more KS 1/EYFS resources', despite the CPD being advertised for KS2 trainees.

Overall, the feedback was positive with few negative comments. The comments received from the trainees about the ESEU workshop were very encouraging and shows what a well-designed short CPD session can achieve. Trainee teacher comments on how they will use their newly gained knowledge are shown in Figure.5.

Figure 5 Comments on how the CPD will be used



4. Identifiable pedagogy within the ESEU workshops

CPD of this nature can greatly enhance a trainee's pedagogical content knowledge by providing ideas on how to teach concepts, increasing the trainees' self-efficacy and hence the likelihood that they would use the material in their teaching. Various anecdotal comments from participants after a workshop have been "Oh good, I have to teach soils/rocks in my next teaching practice, so now I know what to do" and "I wish we had had this workshop before my last teaching practice as I had to teach about rocks and soils and really did not understand it, but I do now".

The workshops offer opportunities for discussion and questioning, and for pupils to develop the investigative ideas offered in different ways, to answer their own queries. For example, using the investigation simulating coastal erosion, pupils can change the wave direction and strength, the size of material being moved by the waves and the cliff material composition (more clayey, sandy, gravelly). These different simulations can be linked to real life examples happening around the British coastline, making them very relevant to where the children live or their holiday experiences. Learning becomes more accessible (Balmer, 2019) and connected through noticing the changes in a practical manner, and children can explain the erosion concepts from their observed understanding. Children give verbal feedback from their visual experiences and playing with sand and water has a 'wow' effect which may well be remembered. All the investigations offered in the ESEU CPDs enable a range of concepts to be

examined and taught, which, when investigated at a simple level, applicable to the age of the participants, provides a motivating and therefore hopefully lasting impression.

Trainees commented that providing concrete experiences using local resources would benefit their teaching, as suggested by Fitzgerald (2012). The workshops continually promoted the use of local soils, rocks and fossils and examples relating to the 'real world'. The simulations offered models to help understand concepts such as the water cycle, a difficult idea for children to grasp. The CPD provides effective teaching and learning as well as opportunities to assess children's progress through their oral or written understanding.

The trainees identified ways that they would use their CPD session when in school. A number believed they would be able to use the material directly, during teaching practice. Some also stated that they would have liked to have had the resources and ideas earlier so they could have used them when on teaching practice. Other trainees felt they could modify the ideas to fit their teaching programmes, whilst others said they would share these ideas and use them for planning future work.

The themes categorised by the trainee teachers relate closely to those identified by Guskey (2000) as being important outcomes for an effective CPD. Guskey suggested that CPD can be evaluated at five levels of outcomes:

- level one: participant reactions
- level two: participant learning
- level three: organisational support and change
- level four: participants' use of new knowledge and skills
- level five: student learning outcomes.

Levels one, two and four are applicable here**.**

Level one, participant reactions, can be identified through all the positive and negative statements made by the participants after the CPD (Table 7.5). Of the 49 different points identified, only four are negative, showing that the statements made over the 2009-2015 period indicate positive reactions.

Level two, participant learning, is indicated within the themes in a number of places, not just under 'knowledge giving'. For example, comments such as 'good information given', 'answered participants' questions', and 'discussion/informal experiences' all suggest learning.

Level four, participants' use of new knowledge and skills, has been graphed in Figure 7. 5 and identifies how the participants say they will use the CPD information.

Since these were only trainee teachers participating in the CPD, they had no way of influencing their organisations (level three) or of knowing student outcomes (level five) at the present time.

At the end of the workshop, each primary trainee was given a USB stick, which held a complete set of the materials and instructions used in the workshop, linked to references in KS2 primary science curriculum. This gave rise to the following comments: that the instructions had "clear explanations"; the activities were "instantly available to use in the classroom because of the ease of obtaining resources"; and they gave "good knowledge in a format useful for children and trainees".

5. Discussion of the ESEU CPD results

The results from the analysis of the comments show that participants' feelings towards the workshops were overwhelmingly positive with very few negative comments (1.7%). The CPD provided subject content knowledge (SCK) and the pedagogical content knowledge (PCK) for teaching earth science for trainees with little or no science background, enabling them to use scientific ideas confidently. Trainees stated that the provision of resource materials such as the CDROM, which contained all the investigations and risk assessments would be very useful when teaching this section of the primary science curriculum. Informal discussion revealed that trainees were thinking further than the given ideas, and in fact using the CPD as a starting point for other topics in the primary curriculum; for example, the simulations of coastal erosion, river processes and water cycle can be linked to geography, history, biology, design and technology. This makes the time spent on one CPD time well used.

The main themes identified by the participants – practical, engaging, teaching and resources – all relate to sound pedagogical practices as identified in the ten TLRP principles of effective pedagogy (James & Pollard, 2011). The theme 'practical' embraces interactive, investigative practices, which are valuable and effective. The trainee teachers were motivated and stated under the engaging theme that there was scope for questioning and discussion leading to higher thinking and critical thinking. The' teaching' theme entailed identifying misconception, use of appropriate vocabulary, adaptability and differentiation activities, evoking curiosity and insightfulness, as well as being suitable for planning and later assessment.

As already suggested the workshop identifies with those points identified by Guskey (2000) as being effective CPD outcome levels. The CPD is therefore seen to be an effective teaching strategy in in its design and delivery by its participants, providing an applicable short workshop when using Guskey's criteria.

A further piece of research which looked at the impact of focused CPD on teachers' subject and pedagogical knowledge was undertaken by Scott et al (2010). These researchers stated that where CPD was domain-specific and teachers were able to focus on learning, teachers found the CPD effective and useful. Many respondents in this survey said that they would use the pedagogical ideas in their teaching and that the CPD had provided additional subject content knowledge they could use. Scott et al (2010) looked specifically at secondary physics and chemistry short CPD provision, because of the shortage of secondary physical science teachers. King and Thomas (2012) evaluated short earth science CPD intervention workshops for secondary teachers with similar conclusions. My research suggests that these primary earth science CPD workshops were as effective as these secondary workshops in providing both pedagogical and subject content knowledge.

The ESEU primary teacher trainee evaluation forms had not previously been investigated although analysis of the CPD impact on secondary science teachers and science trainee teachers had been undertaken (Lydon & King, 2009). That analysis of the secondary CPD showed that even though some of the research literature concludes that short-term CPD is not effective, the ESEU CPD led to increases in knowledge and understanding, at least as stated by the participants. Further, a follow-up postal survey of participating secondary teachers carried out a year after the CPD indicated that teacher practices had changed, indicating long-term benefits from these short CPD workshops (Lydon & King, 2009).

The findings from the primary evaluation forms indicate that the workshops given to primary teacher trainees were well received. Comments suggest that the trainee teachers intended to use earth science

in their primary science work because they saw it as being relevant to their pupils' everyday lives. King and Thomas (2012) calculated the impact secondary ESEU short CPD workshops had on the number of trainee teachers, teachers and, using a multiplier gauge, number of students. My research shows how the primary education sector benefitted too, with some 700 primary teachers attending workshops between 2008-2011 (ESEU data), who could influence some 18,000 primary pupils annually. The total number of trainee teachers who had attended the workshops between 2009 and 2015 was 5580 (ESEU data). The majority of these trainees would be teaching pupils in the coming years, adding to the number benefitting from the CPD.

The trainee primary teachers said that the materials fitted in well with their approach to teaching and were relevant to the curriculum. Harlen and Elstgeest (1992) stated that it is important that teachers have their own understanding of a subject before they teach it or explain it to their colleagues. These workshops provide that understanding at an appropriate level for primary science. Unfortunately, it was not possible to follow up with a postal survey of the trainees' teaching practices, as was done for the secondary workshops, since the trainees completed the activities whilst not in permanent employment in schools, the time that has elapsed since the training took place is too great, and contact details are not available.

Overall, the evaluation from these workshops suggests that the trainee teachers will use the materials to the benefit of their primary pupils with confidence. This evaluation shows that the workshops are fulfilling a need, by offering relevant subject and pedagogical knowledge and do increase confidence in teaching primary science. The trainees were devising their own plans for implementing these investigations, which will surely enrich their teaching, not just in earth science but by relating the concepts they had learnt to the overall science curriculum.

6. Potential of earth science for the development of primary science

It is interesting that in the data the only science subject many of the primary teacher trainees felt confident about teaching was biology, before participating in the CPD workshops. Perhaps biology is as close as primary and secondary school science gets to looking at science which is relevant to young people? Everyone has some understanding of their own biology, but we rarely develop the science that is around us all the time. The physics strand of the primary science curriculum is often seen as difficult by trainee teachers, who feel less confident when having to teach it (McCrory & Worthington, 2018). Earth science can be used to introduce physics concepts such as forces, using children's relevant experiences of wind and its effects. King (2012) suggested that Earth Science should not only form a significant part of *primary* children's science curriculum but for *all* those children up to age sixteen. Although the present primary science curriculum has included more earth science the linkages are unclear and, as with the rest of this curriculum, topics are isolated where they could be so easily integrated. Why are we not making greater use of earth science everyday materials and events in our primary science teaching, as these are available resources of which we all have experience?

Every child needs to understand their own surroundings and how soils, rocks, weather plants and habitats work together. Surely a better understanding of our own earth science would encourage appreciation of the importance of local changes on a world scale. Now is the time to ensure the next generation have this knowledge and understanding.

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